# Land to the west of Main Road, Kelham
# Flood Risk Assessment and Drainage Strategy

For Sirius Planning
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## Land to the west of Main Road, Kelham

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|---|---|
| Project | Flood Risk Assessment and Drainage Strategy |
| Client | Sirius Planning |
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## Disclaimer

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# EXECUTIVE SUMMARY

The Site would be expected to remain dry in all but the most extreme conditions. The consequences of flooding are acceptable, and the development would be in accordance with the requirements of the National Planning Policy Framework (NPPF). The Proposed Development would be operated with minimal risk from flooding, would not increase flood risk elsewhere and is compliant with the requirements of the NPPF. The Proposed Development will considerably reduce the flood risk posed to the Site and to off-site locations due to the adoption of a Sustainable Drainage Systems (SuDS) Strategy.

The Proposed Development should not therefore be precluded on the grounds of flood risk or drainage.

# 1.0 INTRODUCTION

## 1.1 Background

This Flood Risk Assessment and Drainage Strategy (FRA) has been prepared by KRS Enviro at the request of Sirius Planning to support a planning application for the development of a Solar Farm and Battery Energy Storage System (BESS) ("the Proposed Development") on land west of Main Road, Kelham ("the Site").

This FRA has been carried out in accordance with guidance contained in the National Planning Policy Framework (NPPF)[1], associated Planning Practice Guidance on flood risk and coastal change[2] (PPG) and the PPG 'Site-specific flood risk assessment checklist. This FRA identifies and assesses the risks of all forms of flooding to and from the development and demonstrates how these flood risks will be managed so that the development remains safe throughout the lifetime, taking climate change into account.

It is recognised that developments which are designed without regard to flood risk may endanger lives, damage property, cause disruption to the wider community, damage the environment, be difficult to insure and require additional expense on remedial works. The development design should be such that future users will not have difficulty obtaining insurance or mortgage finance, or in selling all or part of the development, as a result of flood risk issues.

## 1.2 National Planning Policy Framework (NPPF)

One of the key aims of the NPPF is to ensure that flood risk is taken into account at all stages of the planning process; to avoid inappropriate development in areas at risk of flooding and to direct development away from areas of highest risk.

It advises that where new development is exceptionally necessary in areas of higher risk, this should be safe, without increasing flood risk elsewhere, and where possible, reduce flood risk overall. A risk-based approach is adopted at stages of the planning process, applying a source pathway receptor model to planning and flood risk. To demonstrate this, an FRA is required and should include:

- whether a proposed development is likely to be affected by current or future flooding from all sources;
- whether it will increase flood risk elsewhere;
- whether the measures proposed to deal with these effects and risks are appropriate;
- if necessary, provide the evidence to the Local Planning Authority (LPA) that the Sequential Test can be applied; and
- whether the development will be safe and pass part c) of the Exception Test if this is appropriate.

The report findings are based upon professional judgement and are summarised below with detailed recommendations provided at the end of the report. The report includes rainfall data

[1] Ministry for Housing, Communities and Local Government (2023) National Planning Policy Framework: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1005759/NPPF_July_2021.pdf
[2] Communities and Local Government (2022) Planning Practice Guidance - Flood Risk and Coastal Change: https://www.gov.uk/guidance/flood-risk-and-coastal-change

from the Flood Estimation Handbook (FEH) and hydrogeological information from the British Geological Survey (BGS). The assessment will summarise and refer to these datasets in the text.

## 1.3 Report Structure

This FRA has the following report structure:

- Section 2 describes the location and the existing and Proposed Development;
- Section 3 outlines the flood risk to the existing and Proposed Development;
- Section 4 details the proposed surface water drainage for the Site and assesses the potential impacts of the Proposed Development on surface water drainage;
- Section 5 provides details of the mitigation measures used to manage the flood risk; and
- Section 6 details the Sequential and Exception Tests;
- Section 7 presents a summary and conclusions.

# 2.0 LOCATION & DEVELOPMENT DESCRIPTION

## 2.1 Site Location

The Site is located on land west of Main Road, Kelham (see Figure 1). The National Grid Reference (NGR) of the approximate centre of the Site is 476610, 355498.

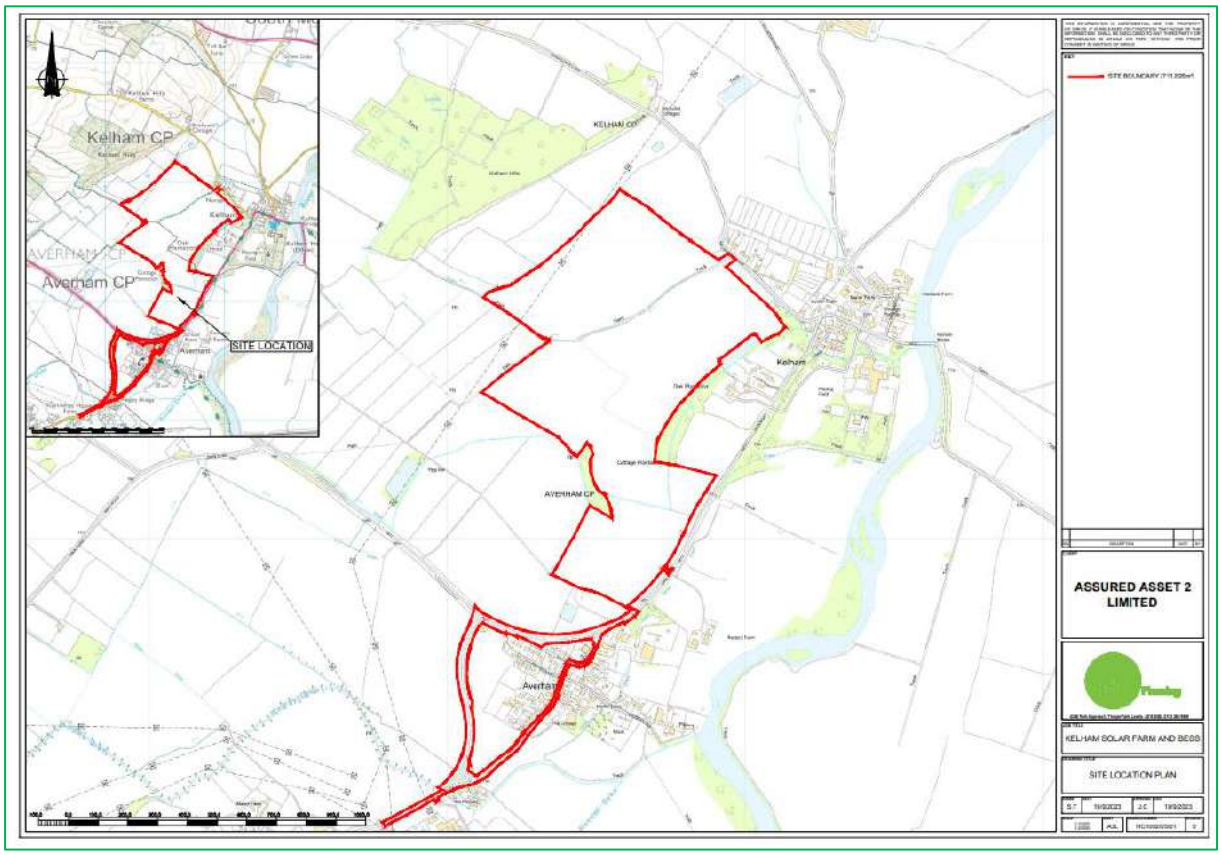



**Figure 1 - Site Location**

## 2.2 Existing Development

The existing Site is currently agricultural land.

## 2.3 Proposed Development

The Proposed Development is for a Solar Farm and Battery Energy Storage System (BESS) together with associated infrastructure (see Appendix 1). Further details with regard to the Proposed Development can be found in the accompanying information submitted with the planning application.

## 2.4 Ground Levels

A topographical survey of the Site has recently been completed (see Appendix 2). The Site is relatively flat with a minimum ground level of approximately 11 metres Above Ordnance Datum (mAOD) to the eastern boundary and a maximum ground level of approximately 13mAOD to the north west of the Site.

## 2.5 Catchment Hydrology / Drainage

There are a number of drainage ditches located within the Site. There are several unnamed ponds within the vicinity of the Site, the closest being adjacent to the eastern boundary of the Site. There is an unnamed watercourse running along the eastern and south eastern boundary, which is a tributary of the River Trent and the River Trent is located approximately 790m to the east of the Site (see Figure 2).

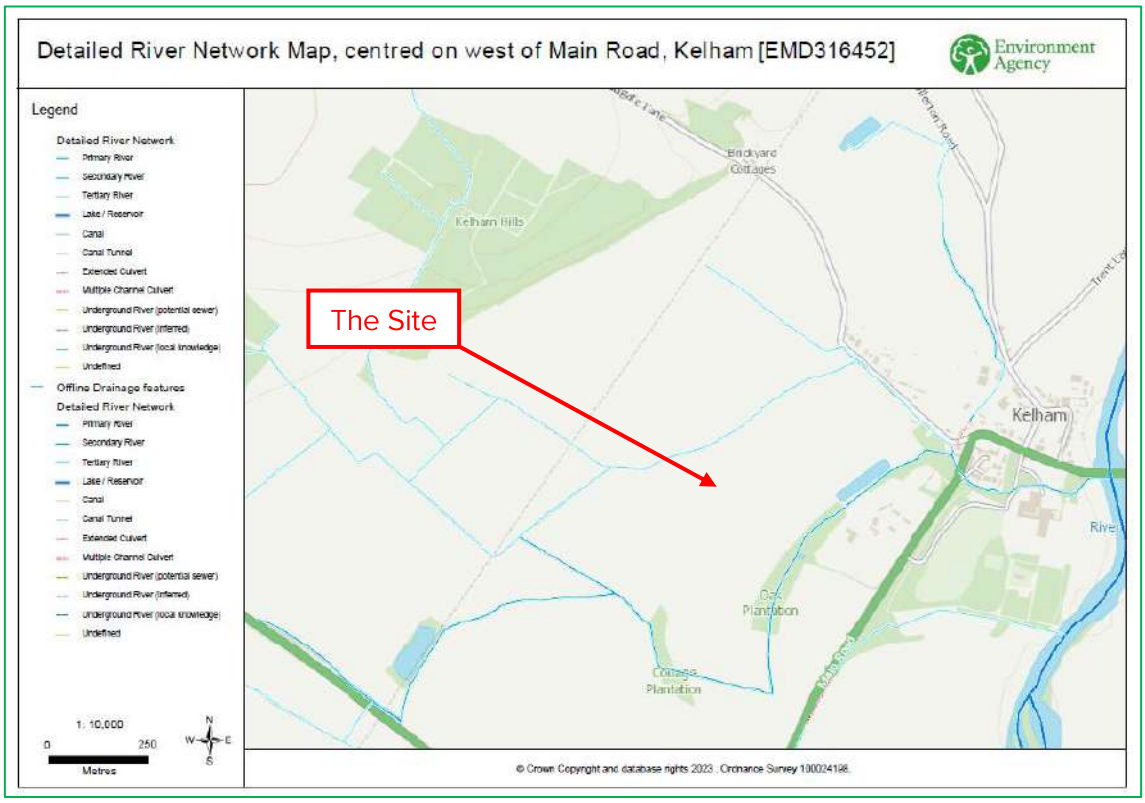



**Figure 2 - Environment Agency Detailed River Network Map**

## 2.6 Ground Conditions

The British Geological Survey (BGS) map shows that the superficial deposits which underlay the Site consist of Holme Pierrepont Sand and Gravel Member - sand and gravel. The bedrock deposits consist of the Mercia Mudstone Group - mudstone. Information from the National Soil Resources Institute details the Site area as being situated on naturally wet loamy soils with naturally high groundwater.

## 2.7 Source Protection Zone

The Site is not located within a Source Protection Zone (SPZ). SPZ's have been defined by the Environment Agency around major public water supplies with the intent to show the risk of contamination from any activities that might cause pollution in the area. Three zones are defined: SPZ 1 is the Inner Zone (highest risk); SPZ 2 is the Outer Zone (average risk); and SPZ 3 is the Total Catchment (least risk).

# 3.0 FLOOD RISK

## 3.1 Sources of Flooding

All sources of flooding have been considered, these are; fluvial (river) flooding, tidal (coastal) flooding, groundwater flooding, surface water (pluvial) flooding, sewer flooding and flooding from artificial drainage systems/infrastructure failure.

## 3.2 Environment Agency

Information regarding the current flood risk at the application Site and local flood defences has been obtained from the Environment Agency (see Appendix 3).

## 3.3 Trent Valley Internal Drainage Board

There are a number of drains within the vicinity of the Site, these are managed by the Trent Valley Internal Drainage Board (IDB). Information regarding the current flood risk at the application site and drainage issues has been obtained from the Trent Valley IDB.

## 3.4 Environment Agency Flood Zones

A review of the Environment Agency's Flood Zones indicates that the majority of the Site is located within Flood Zone 1 and therefore has a 'low probability' of flooding, as shown in Figure 4. Flood Zone 1 has a less than a 1 in 1000 annual probability of river flooding in any year (<0.1%).

There are several small areas of the Site which are located within Flood Zone 2 and therefore have a 'medium probability' of flooding. Flood Zone 2 has between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% - 0.1%) in any year. A small section of the access road to the south is located within Flood Zone 3 and therefore has a 'high probability' of flooding with a 1 in 100 or greater annual probability of river flooding (>1%) in any year.

It should be noted that only a small section of the access road will be located within Flood Zone 3, the built development will not be located within Flood Zone 3.

The Flood Zones are the current best information on the extent of the extremes of flooding from rivers or the sea that would occur without the presence of flood defences, because these can be breached, overtopped and may not be in existence for the lifetime of the development. They show the worst case scenario.

The Environment Agency Flood Zones and acceptable development types are explained in Table 1. Table 2 shows that most development types are generally acceptable in Flood Zones 1, 2 and 3.

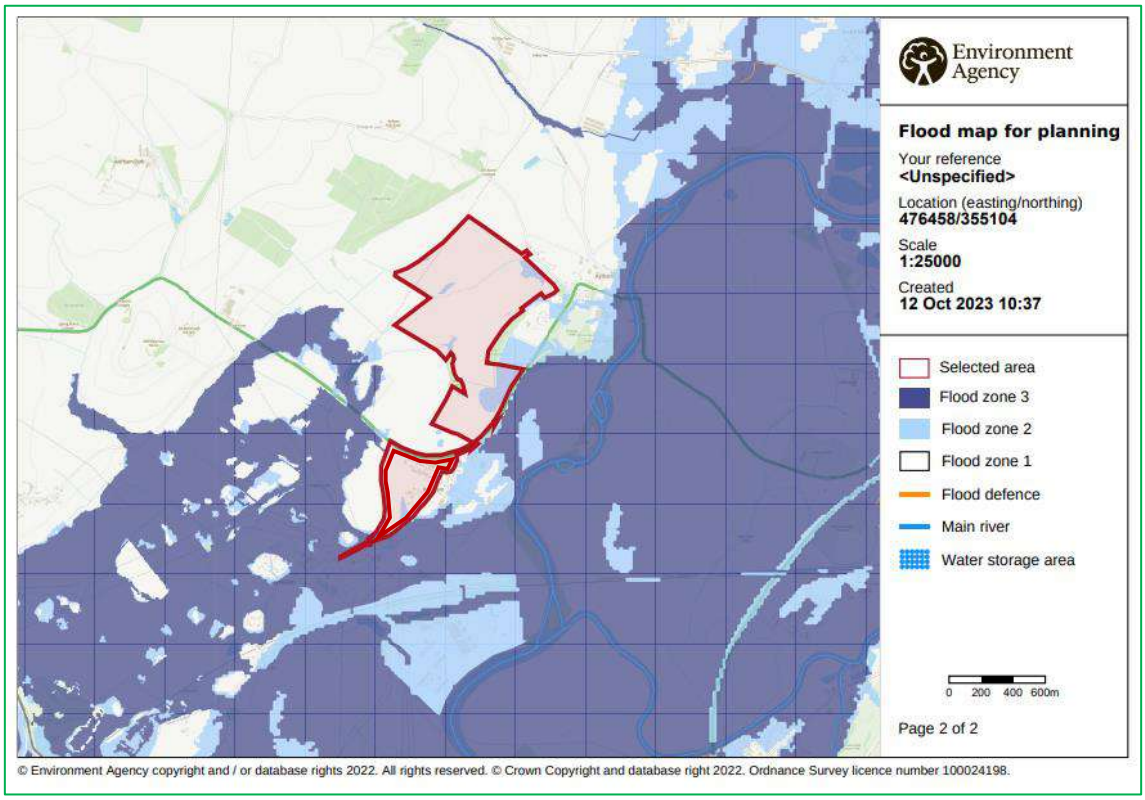



**Figure 2 - Environment Agency Flood Zones**

**Table 1 - Environment Agency Flood Zones and Appropriate Land Use**

| Flood Zone | Probability | Explanation | Appropriate Land Use |
|---|---|---|---|
| Zone 1 | Low | Less than a 0.1% chance of river or sea flooding in any year (1 in 1000 annual probability) | All development types generally acceptable |
| Zone 2 | Medium | Between a 1% - 0.1% chance of river flooding in any year (1 in 100 and 1 in 1000 annual probability) or between a 0.5% - 0.1% chance of sea flooding in any year (1 in 200 and 1 in 1000 annual probability) | Most development type are generally acceptable |
| Zone 3a | High | A 1% or greater chance of river flooding in any year (1 in 100 annual probability) or 0.5% or greater chance of sea flooding in any year (1 in 200 annual probability) | Some development types not acceptable |
| Zone 3b | 'Functional Floodplain' | This zone comprises land where water from rivers or the sea has to flow or be stored in times of flood. The identification of functional floodplain should take account of local circumstances and not be defined solely on rigid probability parameters. Functional floodplain will normally comprise:<br><br>• land having a 3.3% or greater annual probability of flooding, with any existing | Some development types not acceptable |

| | | | |
|---|---|---|---|
| | | flood risk management infrastructure operating effectively; or<br>• land that is designed to flood (such as a flood attenuation scheme), even if it would only flood in more extreme events (such as 0.1% annual probability of flooding).<br>Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency. (Not separately distinguished from Zone 3a on the Flood Map) | |

## 3.5 Flood Vulnerability

In the PPG, appropriate uses have been identified for the Flood Zones. Applying the Flood Risk Vulnerability Classification in the PPG, the proposed use is classified as 'essential infrastructure'. The proposed access road can be classified as 'less vulnerable'. It should be noted that only a small section of the access road will be located within Flood Zone 3, the built development (i.e. essential infrastructure) will not be located within Flood Zone 3.

Table 2 of this report and the PPG states that the Proposed Development is appropriate within Flood Zones 1, 2 and 3 after the completion of a satisfactory FRA.

**Table 2 - Flood Risk Vulnerability and Flood Zone 'Compatibility'**

| Flood Risk Vulnerability Classification | Essential Infrastructure | Water Compatible | Highly Vulnerable | More Vulnerable | Less Vulnerable |
|---|---|---|---|---|---|
| Zone 1 | ✓ | ✓ | ✓ | ✓ | ✓ |
| Zone 2 | ✓ | ✓ | Exception test required | ✓ | ✓ |
| Zone 3a | Exception test required | ✓ | × | Exception test required | ✓ |
| Zone 3b 'Functional Floodplain' | Exception test required | ✓ | × | × | × |

***Key:*** *✓: Development is appropriate, ×: Development should not be permitted.*

## 3.6 Climate Change

Projections of future climate change, in the UK, indicate more frequent, short-duration, high intensity rainfall and more frequent periods of long duration rainfall. Guidance included within the NPPF recommends that the effects of climate change are incorporated into FRA's. Recommended precautionary sensitivity ranges for peak rainfall intensities and peak river flows are outlined in the flood risk assessments: climate change allowances guidance[3]. Table 3 shows peak river flow allowances by river catchment.

As per Environment Agency guidance, the anticipated lifetime of the development is deemed to be 75 years. The flood risk assessments: climate change allowances guidance recommends

[3] https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#high-allowances

that for 'essential infrastructure' in Flood Zones 2 or 3 that the higher central allowances are used. Therefore, the design flood event for the Site is the 1 in 100 year (+39%) event.

**Table 3 - Peak River Flow Allowances by River Catchment**

| Catchment | Allowance Category | 2020s | 2050s | 2080s |
|---|---|---|---|---|
| Lower Trent and Erewash Management Catchment | Upper | +29% | +38% | +62% |
| | Higher | +18% | +23% | +39% |
| | Central | +13% | +17% | +29% |

## 3.7 Historic Flooding

Environment Agency data shows that the Site has not historically flooded. There are no records of anecdotal information of flooding at the Site including within the British Hydrological Society "Chronology of British Hydrological Events". No other historical records of flooding for the Site have been recorded. Therefore, it has been concluded that the Site has not flooded within the recent past.

## 3.8 Existing and Planned Flood Defence Measures

Environment Agency data shows that the Site is protected against flooding by existing flood defence measures (see Figure 3). The Trent Valley IDB through the operation and maintenance of its pumping stations, associated structures and channel systems, the Trent Valley IDB seeks to maintain a general standard capable of providing flood protection to its district. A routine maintenance programme is in place to ensure that the Boards assets are commensurate with the standard of protection that is sought.

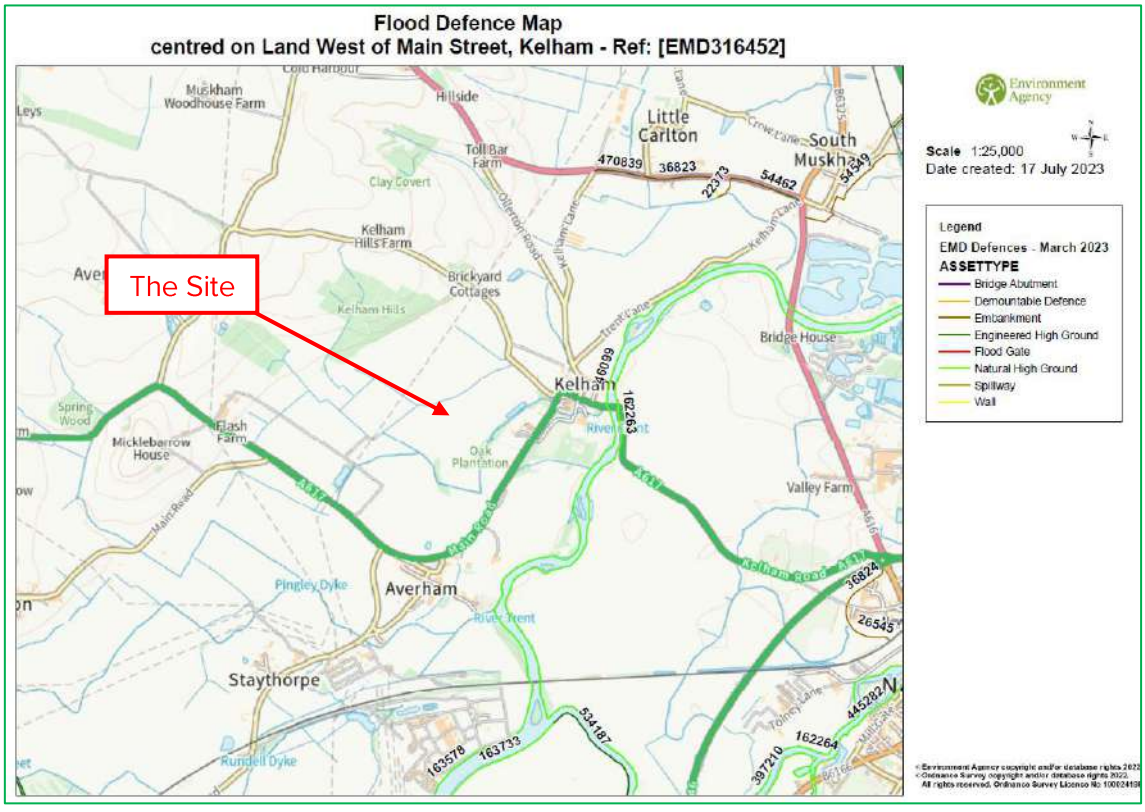



**Figure 3 - Environment Agency Flood Defence Map**

## 3.9 Fluvial (River) Flooding

Fluvial flooding from the River Trent poses the primary but unlikely flood risk to the Site. The Environment Agency has supplied modelled data from the Trent and Tributaries model. The Environment Agency's modelled data has been compared to the Site Ground levels and areas within the vicinity of the Site to assess the flood risk in detail.

Figures 4 to 8 show that the Site, including the access road, will not be inundated with floodwater for all events up to and including the 1 in 100 year (+50%) and 1 in 1000 year events. Between the Site and the River Trent, the ground levels along Main Road (A617) rise to above 12.50mAOD i.e. above the modelled water levels for the 1 in 100 year (+50%) and 1 in 1000 year events. The Site will be flood free during the 1 in 100 year (+50%) and 1 in 1000 year events. Therefore, the Site will also be flood free during the design event for the Site i.e. the 1 in 100 year (+39%) event. The Site, including the access road, should therefore, be designated as being located within Flood Zone 1 and not Flood Zones 2 or 3.

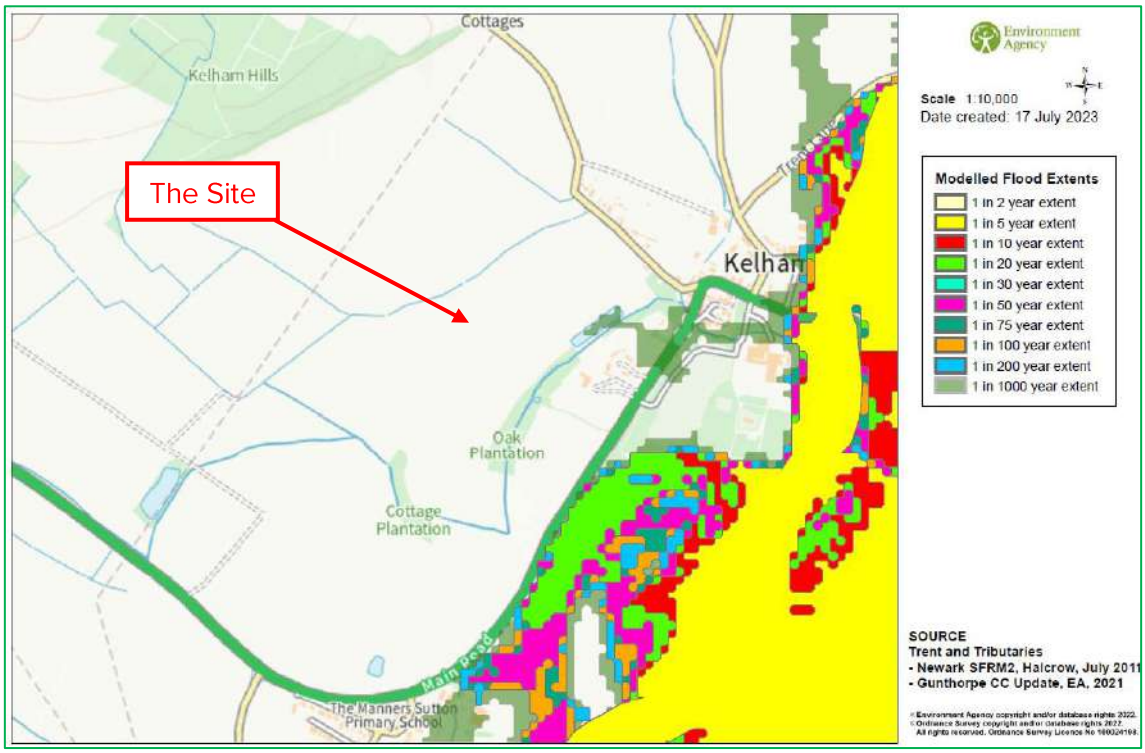



**Figure 4 - Environment Agency Modelled Flood Outlines**

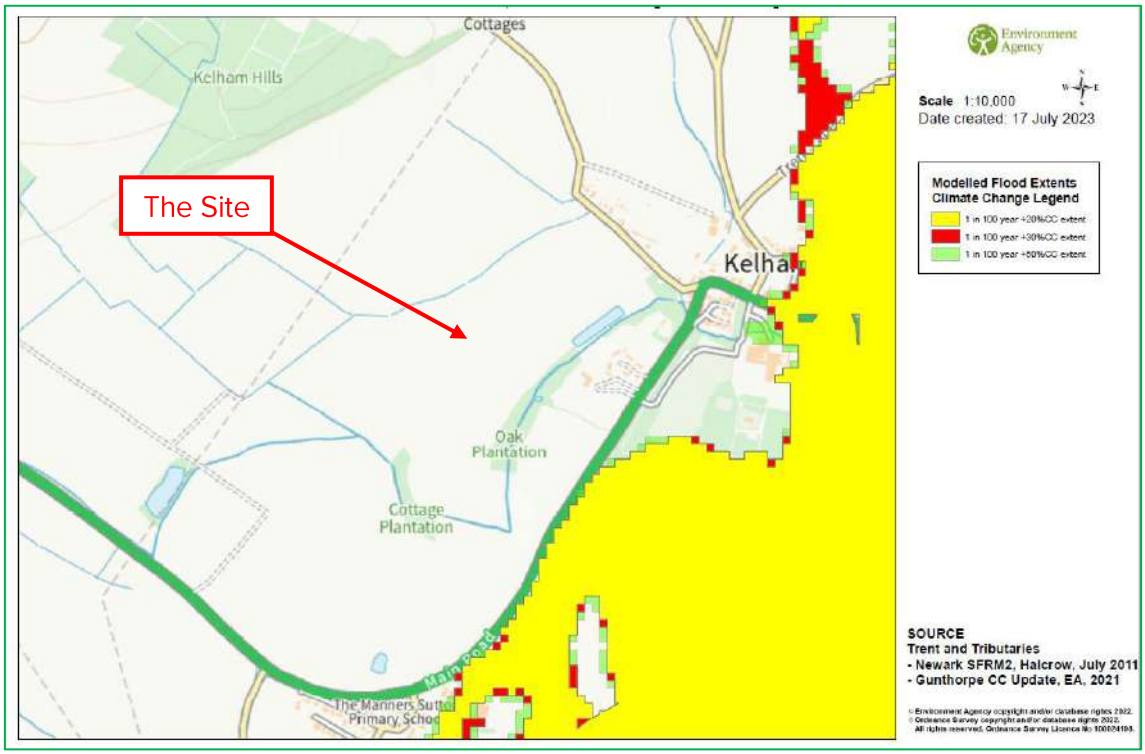



**Figure 5 - Environment Agency Climate Change Modelled Flood Outlines**

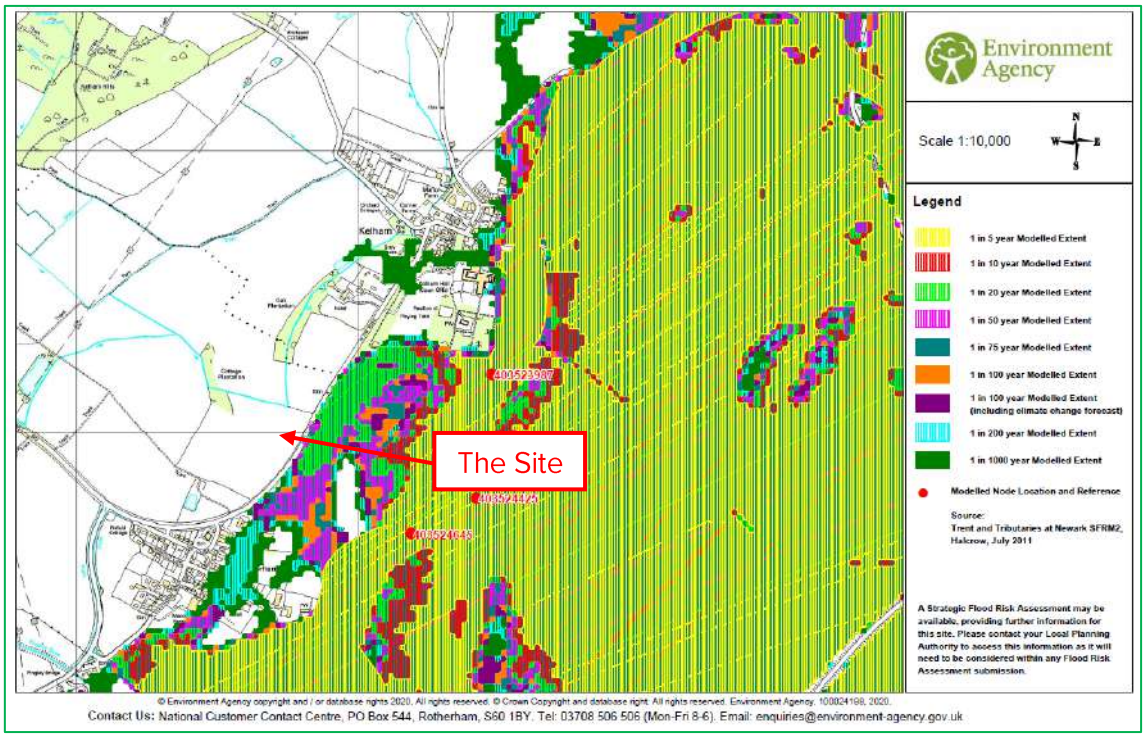



**Figure 6 - Environment Agency Modelled Flood Outlines**


**Figure 7 - Environment Agency Modelled 1 in 100 Year (+50%) Water Levels (mAOD)**

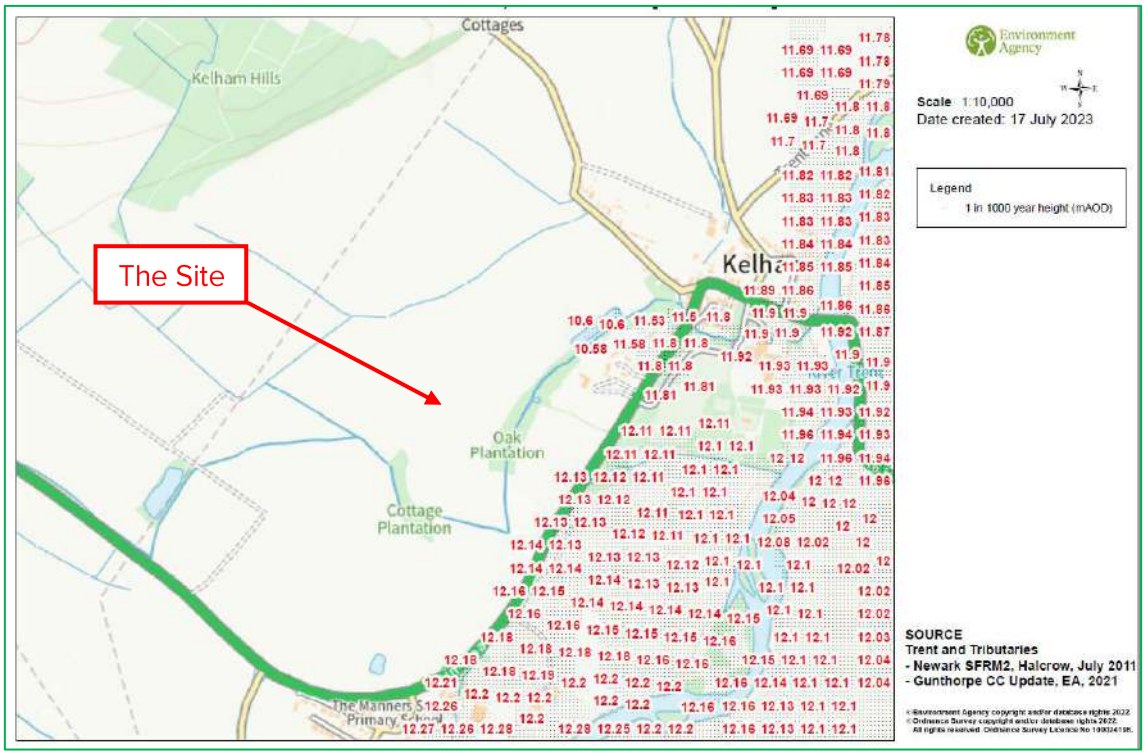



**Figure 8 - Environment Agency Modelled 1 in 1000 Year Water Levels (mAOD)**

The Site is one of the last places in the area to flood and remains flood free when other areas close by are flooded. The Site is at such a ground level that it would only flood in the most extreme flood events; the Site will remain flood free for the vast majority of flood events during the lifetime of the Proposed Development.

The likelihood of a rapid river level rise and possible rapid inundation of urban areas posing a risk to life is considered to be minimal. Any flooding would be of a minor nature due to the low flows and topography of the area. The flooding will only inundate the area to a relatively low water depth and water velocity, will only last a short period of time, in very extreme cases.

Given the small scale and nature of the Proposed Development, and the size and location of the fluvial flooding sources it has been concluded that the risk of fluvial flooding is considered to be of low significance.

## 3.10 Tidal (Coastal) Flooding

The Site is not located within the vicinity of tidal flooding sources and the risk of tidal flooding is considered to be not significant.

## 3.11 Groundwater Flooding

Groundwater flooding is defined as the emergence of groundwater at the ground surface or the rising of groundwater into man-made ground under conditions where the normal range of groundwater levels is exceeded.

Groundwater flooding tends to occur sporadically in both location and time. When groundwater flooding does occur, it tends to mostly affect low-lying areas, below surface infrastructure and buildings (for example, tunnels, basements and car parks) underlain by permeable rocks (aquifers). Site ground conditions suggest a low potential for groundwater flooding. The risk of flooding from groundwater flooding is considered to be not significant.

## 3.12 Surface Water (Pluvial) Flooding

The Site is not situated near to large areas of poor permeability which may result in surface water flooding. The Environment Agency Surface Water flood map shows that the majority of the Site has a very low risk of surface water flooding (see Figure 9) with a chance of flooding of less than 1 in 1000 (0.1%) years. However, small areas of the Site have a low to high risk of surface water flooding with a chance of flooding of between 1 in 1000 (0.1%) and greater than 1 in 30 (3.3%) years.

These areas correspond with the drainage ditches within the Site and the unnamed watercourse running along the eastern and south east boundary. This may result in water depths of less than 300mm.

Given the scale and nature of the Proposed Development and the size and location of the surface water flooding sources it has been concluded that surface water flooding poses a low flood risk to the Site and the risk of surface water flooding is considered to be of low significance.

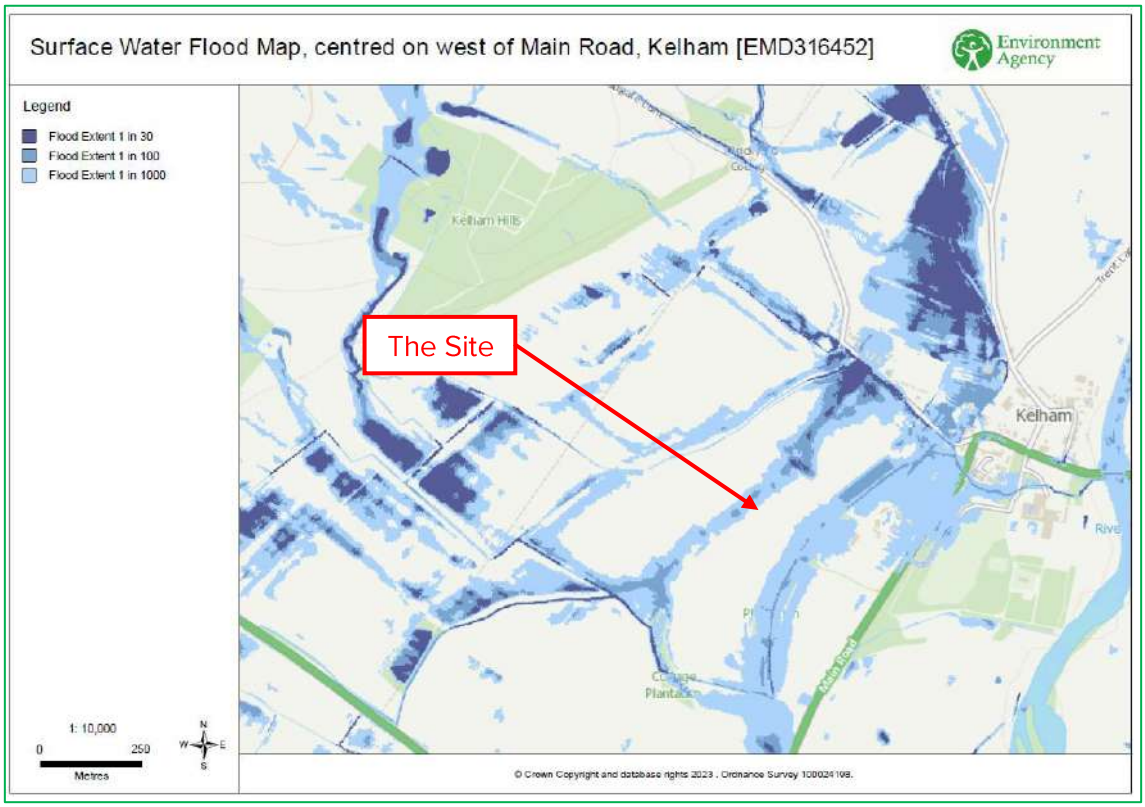



**Figure 8 - Environment Agency Surface Water Flood Map**

## 3.13 Sewer Flooding

Sewer flooding occurs when urban drainage networks become overwhelmed and maximum capacity is reached. This can occur if there is a blockage in the network causing water to back up behind it or if the sheer volume of water draining into the system is too great to be handled. Sewer flooding tends to occur sporadically in both location and time such flood flows would tend to be confined to the streets around the development. Flood flows could also be generated by burst water mains, but these would tend to be of a restricted and much lower volume than weather generated events and so can be discounted for the purposes of this assessment. There are no public sewers located within the vicinity of the Site therefore, the risk of flooding from sewer flooding is considered to be not significant.

## 3.14 Flooding from Artificial Drainage Systems/Infrastructure Failure

Reservoirs are located within the vicinity of the Site. The Environment Agency flood map shows that the Site is at risk of reservoir flooding when there is also flooding from rivers (see Figure 9). This map shows the largest area that might be flooded if a reservoir were to fail and release the water it holds. The Environment Agency Reservoir flood map has been prepared for emergency planning purposes and for this reason they reflect a worst-case scenario. Since this is a prediction of a worst-case scenario, it is unlikely that any actual flood would be this large.

Reservoir flooding is extremely unlikely; reservoirs in the UK have a very good safety record. There has been no loss of life in the UK from reservoir flooding since 1925. Since then reservoir safety legislation has been introduced to make sure reservoirs are well maintained.

The hazard is well managed through effective legislation and it is unlikely that the impact zone downstream of these reservoirs should not preclude the Proposed Development. The risk of flooding from artificial drainage systems/infrastructure failure is considered to be not significant.

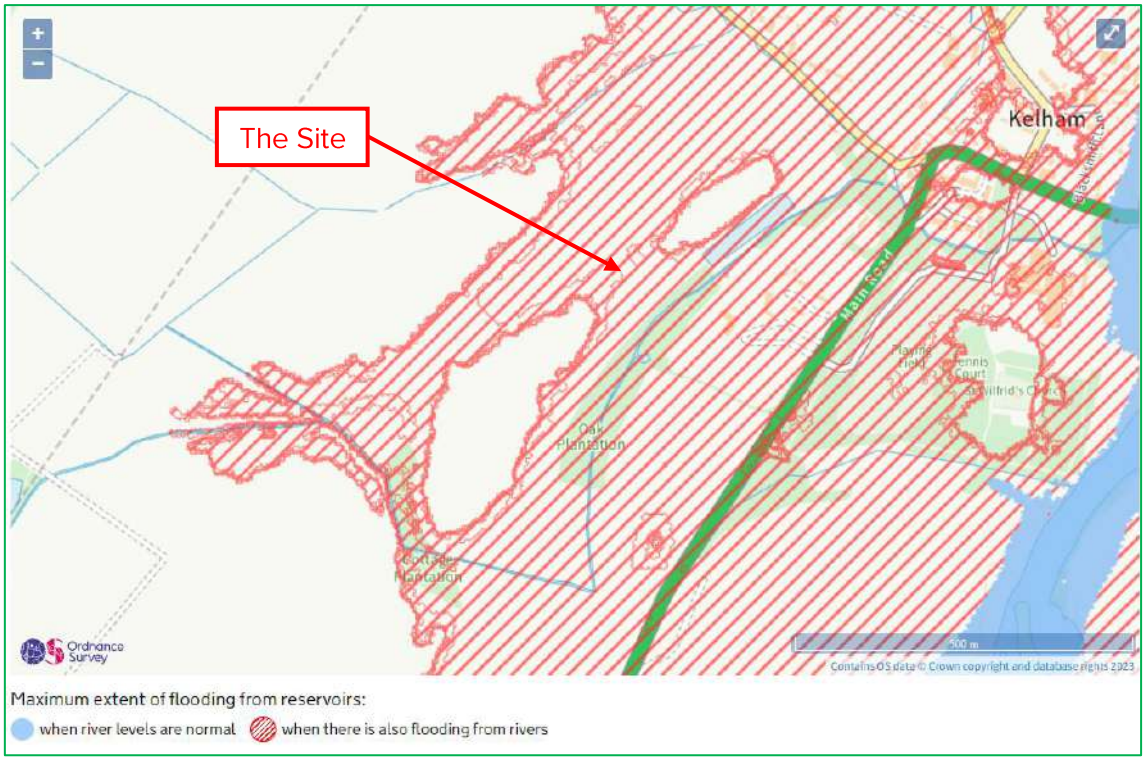



**Figure 9 - Environment Agency Reservoir Flood Map**

## 3.15 The Effect of the Development on Flood Risk

The Site will be flood free during the 1 in 100 year (+50%) and 1 in 1000 year events. The Site, including the access road, should therefore, be designated as being located within Flood Zone 1 and not Flood Zones 2 or 3. The Proposed Development will have no impact on flood risk and the overall direction of the movement of water will be maintained within the developed Site and surrounding area. There will no net loss in flood storage capacity. Any changes in topography will be minor and will not be located within the floodplain.

## 3.16 Summary of Site Specific Flood Risk

A summary of the sources of flooding and a review of the risk posed by each source at the Site is shown in Table 4.

The Site is unlikely to flood except in extreme conditions. The principal flood risk posed to the Site is from fluvial flooding from the River Trent. The majority of the Site is located within Flood Zone 1 and therefore have a 'low probability' of fluvial flooding. There are several small areas of the Site which are located within Flood Zone 2 and therefore have a 'medium probability' of fluvial flooding and only a small section of the access road to the south is located within Flood Zone 3 and therefore have a 'high probability' of fluvial flooding.

The proposed use is classified as 'essential infrastructure'. The proposed access road can be classified as 'less vulnerable'. It should be noted that only a small section of the access road

will be located within Flood Zone 3, the built development (i.e. essential infrastructure) will not be located within Flood Zone 3.

The Environment Agency modelled data shows that the Site, including the access road, will not be inundated with floodwater for all events up to and including the 1 in 100 year (+50%) and 1 in 1000 year events. Between the Site and the River Trent, the ground levels along Main Road (A617) rise to above 12.50mAOD i.e. above the modelled water levels for the 1 in 100 year (+50%) and 1 in 1000 year events. The Site will be flood free during the 1 in 100 year (+50%) and 1 in 1000 year events. Therefore, the Site will also be flood free during the design event for the Site i.e. the 1 in 100 year (+39%) event. The Site, including the access road, should therefore, be designated as being located within Flood Zone 1 and not Flood Zones 2 or 3.

Given the scale and nature of the fluvial flooding sources it has been concluded that the risk of fluvial flooding is considered to be of low significance. A secondary flooding source has been identified which may pose a low significant risk to the Site. This is:

- Surface Water Flooding

The flooding source will only inundate the Site to a relatively low water depth and water velocity, will only last a short period of time, in very extreme cases and will not have an impact on the whole of the Site. The risk of flooding from all sources will be further managed and mitigated by using a number of mitigation measures to manage and reduce the overall flood risk at the Site (see Section 5.0).

The Site will be flood free during the 1 in 100 year (+50%) and 1 in 1000 year events. The Site, including the access road, should therefore, be designated as being located within Flood Zone 1 and not Flood Zones 2 or 3. The Proposed Development will have no impact on flood risk and the overall direction of the movement of water will be maintained within the developed Site and surrounding area. There will no net loss in flood storage capacity. Any changes in topography will be minor and will not be located within the floodplain.

In conclusion, the flood risk to the Site can be considered to be limited, the Site is unlikely to flood except in very extreme conditions.

**Table 4 - Risk Posed by Flooding Sources**

| Sources of Flooding | Potential Flood Risk | Potential Source | Probability/Significance |
|---|---|---|---|
| Fluvial Flooding | Yes | River Trent | Low |
| Tidal Flooding | No | None Reported | None |
| Groundwater Flooding | No | None Reported | None |
| Surface Water Flooding | Yes | Low Spots / Drainage Ditches | Low |
| Sewer Flooding | No | None Reported | None |
| Flooding from Artificial Drainage Systems/Infrastructure Failure | Yes | Reservoirs | None |

# 4.0 SURFACE WATER DRAINAGE

## 4.1 Surface Water Management Overview

It is recognised that consideration of flood issues should not be confined to the floodplain. The alteration of natural surface water flow patterns through developments can lead to problems elsewhere in the catchment, particularly flooding downstream. For example, replacing vegetated areas with roofs, roads and other paved areas can increase both the total and the peak flow of surface water runoff from the Site. Changes of land use on previously developed land can also have significant downstream impacts where the existing drainage system may not have sufficient capacity for the additional drainage.

An assessment of the surface water runoff rates has been undertaken, in order to determine the surface water options and attenuation requirements for the Site. The assessment considers the impact of the proposals compared to current conditions. Therefore, the surface water attenuation requirement for the developed Site can be determined and reviewed against existing arrangements.

The requirement for managing surface water runoff from developments depends on the pre-developed nature of the Site. If it is an undeveloped Greenfield site, then the impact of the proposals will need to be mitigated so that the runoff from the Site replicates the natural drainage characteristics of the pre-developed Site. The surface water drainage arrangements for any site should be such that the volumes and peak flow rates of surface water leaving a site are no greater than the rates prior to the Proposed Development unless specific off-site arrangements are made and result in the same net effect.

It should be acknowledged that the satisfactory collection, control and discharge of surface water runoff are now a principle planning and design consideration. This is reflected in recently implemented guidance and the National Sustainable Drainage Systems (SuDS) Standards. It is necessary to demonstrate that the surface water from the proposals can be discharged safety and sustainably.

## 4.2 Climate Change

Projections of future climate change, in the UK, indicate more frequent, short-duration, high intensity rainfall and more frequent periods of long duration rainfall. Guidance included within the NPPF recommends that the effects of climate change are incorporated into FRA's. Recommended precautionary sensitivity ranges for peak rainfall intensities and peak river flows are outlined in the flood risk assessments: climate change allowances guidance[4]. The recommended precautionary sensitivity range for peak rainfall intensity are summarised in Table 5.

**Table 5 - Peak Rainfall Intensity Allowances**

| Catchment | Parameter | 2050s | 2070s |
|---|---|---|---|
| Lower Trent and Erewash Management Catchment | Upper End | +40% | +40% |
| | Central | +20% | +25% |

[4] https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#high-allowances

## 4.3 Opportunities to Discharge of Surface Water

Possible receptors for runoff generated onsite have been assessed in line with the prioritisation set onsite out in the Defra non-statutory technical standards for SuDS. There are four possible options to discharge the surface water. The Runoff Destination is (in order of preference):

a) To ground;

b) To surface water body;

c) To road drain or surface water sewer;

d) To combined sewer

It is necessary to identify the most appropriate method of controlling and discharging surface water. The design should seek to improve the local runoff profile by using systems that can either attenuate runoff and reduce peak flow rates or positively impact on the existing surface water runoff.

### 4.3.1 Discharge to Ground

In determining the future surface runoff from the Site, the potential of using infiltration has been considered. Whilst the permeability and infiltration rate of the Site would be confirmed by a Site investigation into the hydrogeology prior to construction, the ground conditions suggest infiltration would provide inception storage, but disposal of significant volumes of runoff may not be appropriate.

### 4.3.2 Discharge to Surface Water Body

There are a number of drainage ditches located within the vicinity of the Site. Therefore, it would be possible to discharge surface water runoff from the Site into a watercourse. This is the preferred option for the discharge of surface water runoff from the Site. Discharge into a watercourse would be restricted to Greenfield runoff rates.

### 4.3.3 Discharge to Surface Water or Combined Sewer

In the event that discharge of surface water via infiltration or discharge to a watercourse is deemed unsuitable, then discharge to the public sewer may be possible. This option is not required as the surface water runoff from the Site will discharge to a watercourse.

### 4.3.4 Summary

For the purposes of this assessment, discharging surface water runoff to the ground via infiltration is the preferred option for the discharge of surface water runoff from the Site, with a secondary option of discharge to a drainage ditch, at Greenfield runoff rates.

## 4.4 Surface Water Runoff Rates

Currently the majority of rainfall infiltrates into the soil substrate and/or runoff from the Site. An estimation of surface water runoff is required to permit effective Site surface water management and prevent any increase in flood risk to off-site receptors.

In accordance with The SuDS Manual, the Greenfield runoff from the Site has been calculated using the Institute of Hydrology 124 (IoH124) method. Table 6 shows the IoH 124 method Greenfield runoff rates calculated for the areas of the proposed substations and containers of 2,223m$^2$. The mean annual maximum flow rate from a Greenfield site (QBAR: approximately a 2.30 year return period) has been calculated to be 0.87 litres/second (l/s) (see Appendix 4).

**Table 6 - IoH124 Method Greenfield Runoff Rates**

| Return Period (yrs) | Runoff Rate (l/s) |
|---|---|
| 1 | 0.72 |
| QBAR (rural) | 0.87 |
| 30 | 1.74 |
| 100 | 2.24 |

The method used for calculating the runoff complies with the NPPF, as well as the Defra non-statutory technical standards for SuDS and assumes that the excess runoff associated with the Proposed Development (plus an allowance for future climate change) will need to be managed by the proposed SuDS scheme.

## 4.5 SuDS Strategy

The objective of this SuDS Strategy is to ensure that a sustainable drainage solution can be achieved which reduces the peak discharge rate to manage and reduce the flood risk posed by the surface water runoff from the Site. The SuDS Strategy takes into account the following principles:

- No increase in the volume or runoff rate of surface water runoff from the Site.
- No increase in flooding to people or property off-site as a result of the development.
- No surface water flooding of the Site.
- The proposals take into account a 40% increase in rainfall intensity due to climate change.
- Maintain / improve surface water quality.
- Provide amenity and biodiversity benefits.

In line with adopting a 'management train' it is recommended that water is managed as close to source as possible. For the purposes of this assessment, discharging surface water runoff to the ground via infiltration is the preferred option for the discharge of surface water runoff from the Site, with a secondary option of discharge to a drainage ditch, at Greenfield runoff rates. This will reduce the size and cost of infrastructure further downstream and also shares the maintenance burden more equitably. The Outline SuDS Strategy will take the form of:

- Permeable surfaces - crushed stone.
- Infiltration trenches.
- Swales.

One of the aims of the NPPF is to provide not only flood risk mitigation but also to maximise additional gains such as improvements in runoff quality and provision of amenity and biodiversity. Systems incorporating these features are often termed SuDS and it is the requirement of NPPF that these are considered as the primary means of collection, control and disposal for storm water as close to source as possible.

The principle applied in the design of storage is to limit the discharge rate of surface water runoff from the developed Site for events of similar frequency of occurrence to the same peak rate of runoff as that which takes place from a Greenfield site prior to development. It would

not be practical to include a pond, or lagoon within the Site it would also not be sustainable to install a green roof on the buildings/structures.

The SuDS Strategy will reduce peak flows, the volume of runoff, and slow down flows and will provide a suitable SuDS solution for this Site. The adoption of a SuDS Strategy for the Site represents an enhancement from the current conditions as the current surface water runoff from the Site is uncontrolled, untreated, unmanaged and unmitigated. In adopting these principles, it has been demonstrated that a scheme can be developed that does not increase the risk of flooding to adjacent properties and development further downstream.

## 4.6 Surface Water Runoff Rate/Volume

*Proposed BESS*

The equipment will sit on uncompacted stone surfacing. The battery units will sit on concrete plinths above the ground. Areas, where possible, will be constructed to shed water to any adjacent permeable areas. The rest of the Site, apart from the roadways, will be constructed from free draining stone or grass which will allow infiltration of rainfall.

The free draining stone will have a sufficient void ratio of 30% and permeability of granular fill to allow adequate percolation and to control the risk of blockage (examples include coarse aggregate 4-40mm (4/40), 4-20mm (4/20) as defined in BS 753313:2009 or Type 3 sub-base 0-40mm (0/40)). A permeable/open-graded (reduced fines) sub-base layer (i.e. Type 3 with a void ratio of 30%) will be used as a drainage layer below the permeable surfaces which will be sufficiently permeable to allow water to drain through and to store water temporarily. The selected gravel fill and bedding would be clean, free-draining, angular shaped material in the specified size range.

Infiltration capacities of free draining stone are significantly greater than the design rainfall intensities and are not a limiting factor. A minimum value of 2500mm/hr is considered reasonable within The SuDS Manual (see Section 20.5.1 of the SuDS Manual). These are SuDS source control compliant and will as a minimum provide storage for the first 5mm (interception storage). Permeable surfaces, together with their associated substructures, are an efficient means of managing surface water runoff close to its source – intercepting runoff, reducing the volume and frequency of runoff, and providing a treatment medium. These systems encourage biological treatment of flow and extraction of oils and heavy metals from the runoff. Treatment processes that occur within the surface structure and the geotextile layers include:

- Filtration
- Absorption
- Biodegradation
- Sedimentation

It will also assist in reducing the flood profile of the Site by significantly attenuating the runoff from the Proposed Development within the sub-base material. The calculations for the infiltration trench is shown in Appendix 4. The calculations include the areas of the infrastructure. A conservative estimate of the infiltration rate of 0.00004m/s has been used. The infiltration trench will allow treatment and attenuation and infiltration into the ground and has been designed to accommodate the 1 in 100 year event plus climate change (+40%) therefore, flooding would not occur for all events up to the 1 in 100 year (+40%) event.

These methods will reduce peak flows, the volume of runoff, and slow down flows and will provide a suitable SuDS solution for this Site. The adoption SuDS features for the Site

represents an enhancement from the current conditions as the current surface water runoff from the Site is uncontrolled, untreated, unmanaged and unmitigated. The SuDS features will reduce the risk of flooding to the Site and off-site locations.

In adopting these principles, it has been demonstrated that a scheme can be developed that does not increase the risk of flooding to adjacent properties and development further downstream.

*Proposed Solar Farm*

The majority of proposed panels will be on standard piles. However, panels over archaeological mitigation areas will be on concrete sleepers. the concrete sleepers will also be raised 300mm to provide a greater depth (to reduce potential compaction of features)

Greenfield conditions will be retained as alluded to in the BRE Planning Guidance for the Development of Large Scale Ground Mounted Solar PV Systems[5]. Although the solar panels will divert the downward path of falling rain, being raised off the ground on frames, they will not reduce the permeable area where they are sited. Any rainfall that does fall onto the Site will, as now, infiltrates into the soil substrate.

It is anticipated that rain falling on each of the solar PV modules will fall underneath the down-slope of the panels. A gap of approximately 20mm will allow water to drain off each PV module (the 20mm gap surrounds all sides of the panels) (see Figure 10). Tussock grasses will dominate around and beneath the photovoltaic panels to limit soil erosion caused by runoff from the panels.

The erection of the solar panels will require the use of light machinery. Care will be taken during the construction to limit the cultivation and disturbance of the ground by plant movement and exposure of soil. However, it is anticipated that this would not lead to irreversible compaction of soils on the Site. However, no work will be undertaken until a perimeter wide cross-contour vegetated swale is constructed around the downstream boundary of the Site which will be along the south and south western boundaries of the Site. Therefore, infiltration should not be limited by compaction of soils. The land on the Site can continue to be used for agricultural purposes (sheep grazing or similar) or for biodiversity enhancement following installation of the panels.

The proposed inverters will be on the racking on the back of the panels and the transformers will be on concrete plinths on stone bases, grid connection and substation structures will be constructed from impermeable surfaces however, these will stand on an area of permeable surfaces. The transformers are positioned on legs raised above the base. The cabin plinths will be founded on concrete pads surrounded by permeable surfaces. Filter strips will be constructed to surround the concrete bases of these ancillary buildings/structures to capture any runoff from the roofs, which in turn will be conveyed to the wide cross-contour perimeter swale around the downstream boundary of the Site.

The proposed access tracks that will be used to service the transformer units will be constructed from permeable material. This will ensure that the access tracks remain permeable allowing surface water to infiltrate into the soil substrate therefore, the access tracks will not result in an increase in the impermeable area. In order to manage any surface water exceedance from the permeable tracks, swales will be incorporated to convey the water to the cross-contour perimeter swale at the downstream boundary of the Site in order to maintain downstream/downslope water quality.

[5] BRE (2013) Planning Guidance for the development of large-scale ground mounted solar PV systems. See comment

There should, therefore, be no perceivable changes to the upstream or downstream hydrology and to flood risk as a result of the proposals. In terms of surface water runoff, the proposals will not increase the impermeable area on the Site, as the size of the inverter house and PV modules are considered to be negligible in the context of the Site areas. Therefore, there will be no perceivable changes to the upstream or downstream hydrology and flood risk as a result of the proposed development.

**Figure 10 - Typical View of Arrays with Joints which Distribute Runoff**

It is generally accepted that the presence of solar panels on a site may slightly change the pattern of runoff with the potential for minor erosion at the base of the panels. There is empirical evidence of the effect of solar development, a recent research paper[6] found that, with well-maintained grass underneath the panels, the solar panels themselves did not have a significant impact on the runoff volumes, peaks or time to peak. Their analysis did find that, with bare ground or gravel cover beneath the panels as a result of design decisions or lack of maintenance, peak discharge may increase resulting in the need for stormwater management.

Natural England has provided guidance on solar parks in the form of Technical Information Note (TIN) 101, although TIN101, it provides useful information. This guidance provides an overview of the potential effects and possible mitigation measures for soil erosion and increased runoff, amongst others. TIN101 states that *"The key to avoiding increased run-off and soil into watercourses is to maintain soil permeability and vegetative cover. Permeable land surfaces underneath and between panels should be able to absorb rainfall as long as they are not compacted and there is some vegetation to bind the soil surface."*

TIN101 concludes that *"the risks of run-off and soil erosion are lowest on low gradient land with cohesive soils and highest on dry, sandy and steeply sloping soil surfaces";* this highlights the effect of slope on runoff rates and soil erosion. Furthermore, the slope aspect of the land can also have an effect on runoff rates and soil erosion. The aspect of the solar panels will always be south-facing (in the UK) and, therefore, north or south facing slopes will result in runoff flowing in a parallel direction to that of the runoff from the panels thereby remaining relatively diffuse and unlikely to result in concentrated flows that could cause soil erosion, apart from where very steep slopes occur.

The Proposed Development is considered to have a relatively low gradient, with south- facing slope. A tussock grassed surface will be maintained at the Site to reduce the likelihood of

[6] Cook and McCuen (2013) Hydrologic Response to Solar Farms, pg 536-541, Journal of Hydrologic Engineering, ACSE, May 2013.

overland flow or soil erosion occurring which, based on this assessment, is considered to be low.

Any local erosion which might result from this trend will be mitigated by the thick sward of tussocky grass germinated both beneath and between the panels and its regime of regular maintenance and therefore, there will be no increase in flood risk off the Site.

*Summary*

As there is no history of surface water flooding at the Site it is likely that the current drainage system is sufficient for the current and proposed site use. The surface water runoff will not increase post-application compared to pre-application and there will be no increase in surface water flood risk to the Site and off-site locations. No changes to the current surface water network are proposed. Following development, surface water flows from the Site will continue to discharge to the ground.

## 4.7 Surface Water Management During Construction

The surface water management during construction will include the following measures:

- Soil management practices to reduce runoff
- Erosion and sediment control
- No works undertaken until a wide perimeter cross-contour vegetated swale is constructed around the downstream boundaries of the Site.

The limits of topsoil stripping will be minimised at the Site to reduce site runoff volumes. Preserving the quantity and quality of the site topsoil is critical to preserving the site runoff rates both during and after construction and to promote stabilisation vegetation establishment. Topsoil stripping will be limited to the areas necessary for access road and construction and for the creation of temporary laydown areas, as required. All stripped topsoil must remain on the Site and be reused for landscaping or restoration.

All access tracks and the compound area will be constructed using permeable granular materials. Vehicular movements will be restricted to the access tracks and designated areas where possible to avoid or limit soil compaction, which could have a detrimental impact on infiltration rates.

*Erosion and Sediment Control Measures*

The various construction activities required to construct the Proposed Development include minor grading activities and general construction traffic. If left unmitigated, these activities will result in impacts ranging from disturbance of soils to potential erosion and sediment transport to offsite locations.

Erosion control will be achieved primarily by:

- Managing disturbed soils using soil conservation practices to reduce runoff and sediment transport during construction.
- Constructing barriers to filter runoff.
- A construction entrance feature (“mud mat”) will be provided at the Site entrance to minimise the offsite transport of sediment via construction vehicles.
- The access road will be cleaned of any sediment deposited by site construction traffic.

- Stabilise topsoil stockpiles expected to be left in place longer than 30 days with vegetative cover (i.e., hydroseeding) or a rolled erosion control product in the event of unfavourable growing conditions (i.e., during the winter).
- Re-vegetate all disturbed areas where construction is not expected for 30 days with a minimum 50mm of topsoil and hydro-seeding or other stabilizing vegetation / erosion protection measures. If vegetation establishment is not possible, given seasonal restriction or other revegetation limiting factors, the disturbed area should be stabilised against erosion impacts by non-vegetated means such as erosion control blankets.
- In the event of inclement weather or unfavourable terrain for construction, construction best practices, such as temporary rig-mats may be used to prevent disruption of surface soils and vegetative cover by construction vehicles and equipment.

The erosion control measures shall be maintained in good repair during the entire construction period and removed as contributing drainage areas are restored and stabilised.

## 4.8 Surface Water Management Post Construction

The following design features will reduce the risks from surface water runoff from solar panels by promoting dispersion and infiltration:

- The gap between panels will be sufficient (typically 20 mm) to allow drainage to ground rather than onto adjacent panels.
- The ground surface around and between the frames will be maintained as grass to ensure that bare soil areas are minimised.
- The vegetated gap between rows of frames will be of greater width than that of each row of solar panels.
- Groundcover vegetation will be maintained in good condition in those areas receiving runoff from solar panels.
- Regular inspections and maintenance of the Site will be undertaken to ensure that vegetation cover is adequate and no rivulets are generated.

Runoff is expected to remain dispersed and unlikely to form channels. Broad grass strips around the edge of the array will also act to impede drainage of surface water to field margins. The proposed transformers will be sufficiently small so that measures to attenuate surface water will not be required. The runoff will shed onto the surrounding ground where it will naturally disperse.

Post-development, the land will become managed pasture without seasonal ploughing. Runoff will therefore contain lower silt loads than currently and perimeter grass strips around fields will reduce runoff to drainage ditches. Managed grassland will offer equivalent or better runoff management than the current situation. Over the long-term, runoff from the area occupied by the solar array is likely to be an improvement on present conditions

The proposed PV modules will consist of an aluminium frame, with stainless steel supports and piles and concrete sleepers. Greenfield conditions will be retained as alluded to in the BRE Planning Guidance for the Development of Large Scale Ground Mounted Solar PV Systems . Although the solar panels will divert the downward path of falling rain, being raised off the ground on frames, they will not reduce the permeable area where they are sited. Any rainfall that does fall onto the Site will, as now, infiltrates into the soil substrate.

It is anticipated that rain falling on each of the solar PV modules will fall underneath the down-slope of the panels. A gap of approximately 20mm will allow water to drain off each PV module (the 20mm gap surrounds all sides of the panels). The land on the Site can continue to be used for agricultural purposes (sheep grazing or similar) or for biodiversity enhancement following installation of the panels.

## 4.9 Designing for Local Drainage System Failure/Exceedance Events

When considering residual risk, it is necessary to make predictions as to the impacts of a storm event that exceeds the design event, or the impact of a failure of the local drainage system. The SuDS Strategy applies a safe and sustainable approach to discharging rainfall runoff from the Site and this reduces the risk of flooding however, it is not possible to completely remove the risk.

As part of the SuDS Strategy it must be demonstrated that the flooding of property would not occur in the event of local drainage system failure and/or design exceedance. It is not economically viable or sustainable to build a drainage system that can accommodate the most extreme events. Consequently, the capacity of the drainage system may be exceeded on rare occasions, with excess water flowing above ground. However, this is considered unlikely in the immediate future due to the 40% allowance for climate change used in the calculations.

The design of the Proposed Development provides an opportunity to manage this local drainage system failure/exceedance flow and ensure that indiscriminate flooding of property does not occur. There will not be an extensive sewerage network on the Proposed Development and therefore it is very unlikely that a catastrophic failure would occur. An exceedance or blockage event of the sewers would not affect the proposed structures as these will be raised above surrounding ground levels, ensuring any exceedance flooding would not affect the buildings/structures. Exceedance flows would be contained within the permeable areas within the Site and would flow to the lower ground levels. It is not considered that there is an increased risk to the Site or properties located adjacent to the Site.

Surface water runoff would be directed to the drainage system through drainage gullies located around the perimeter of the structures and through contouring of the hardstanding areas. When considering the impacts of a storm event that exceeds the design event, there is safety factor, even under the design event conditions. Consequently, if this event were to be exceeded there is additional capacity with the system to accommodate this (i.e. within the manholes, pipes etc.). If this freeboard was to be exceeded the consequences would be similar, if not less than for the local drainage system failure. Consequently, the impact of an exceedance event is not considered to represent any significant flood hazard.

The above manages and mitigates the flood risk from surface water runoff to the adjacent premises and Site infrastructure from surface water runoff generated by the Proposed Development.

## 4.10 Operation and Maintenance Requirements

The following maintenance schedules are based on The SuDS Manual, for standard maintenance regimes. However, planting and maintenance regimes may be changed to enhance biodiversity. In order for any surface water drainage system to operate as originally intended, it is necessary to ensure that it is adequately maintained throughout its lifetime. Therefore, over the lifetime of a development there is strong possibility that the system could either fail or its performance be reduced if it is not correctly maintained. This is even more important when SuDS form part of the SuDS Strategy compared to traditional piped networks.

The surface water drainage scheme will be installed and fully operational before occupation of the Site occurs. The surface water drainage scheme will be regularly maintained. The key maintenance requirements are regular inspection of silt traps, manholes, pipework and pre-treatment devices, with removal of sediment and debris as required.

Regular inspection and maintenance is required to ensure the effective long-term operation of below ground systems. Maintenance responsibility for the system will be placed with the owner of the Site who will employ responsible organisations when required. Specific maintenance needs of the system will be monitored, and maintenance schedules adjusted to suit requirements.

Preventative measures will be taken rather than corrective measures. Preventative maintenance ensures both the condition monitoring and life-extending tasks are carried out at scheduled regular intervals, ensuring failure and regular repair of the system is avoided.

The maintenance requirements comprise:

- General requirements or regular maintenance.
- Occasional tasks.
- Remedial work.
- Collect all litter or other debris and remove it from the Site at each visit
- Avoid use of weed killers and pesticides to prevent chemical pollution.
- Avoid de-icing agents wherever possible.
- Protect all below ground drainage through careful selection and placement of hard and soft landscaping.

### *Permeable Surfaces*

Permeable surfaces are porous to allow rain to percolate through the surface into underlying drainage layers. They must be protected from silt, sand, compost, mulch, etc. Table 7 provides details of the maintenance requirements.

**Table 7 - Permeable Surfaces**

| General Requirements | Frequency |
|---|---|
| Brush regularly and remove sweepings from all hard surfaces | Monthly |
| **Occasional Tasks** | **Frequency** |
| Brush and vacuum surfaces once a year to prevent silt blockages and enhance design life | Annually |
| **Remedial Work** | **Frequency** |
| Monitor effectiveness of permeable surfaces and when water does not infiltrate immediately advise Client of possible need for reinstatement of top layers or specialist cleaning | As Required |
| Recent experience suggests jet washing and suction cleaning will substantially reinstate surfaces to 90% efficiency | As Required |

*Infiltration Trenches*

Infiltration trenches are designed to provide storage and infiltration of surface water. Table 8 provides details of the maintenance requirements.

**Table 8 - Infiltration Trenches**

| General Requirements | Frequency |
|---|---|
| Inspect for sediment and debris in pre-treatment components and floor of inspection tube or chamber and inside of concrete manhole rings | Annually |
| Cleaning of gutters and any filters on downpipes | Annually (or as required based on inspections) |
| Trimming any roots that may be causing blockages | Annually (or as required) |
| **Occasional Tasks** | **Frequency** |
| Remove sediment and debris from pre-treatment components and floor or inspection tube or chamber and inside of concrete manhole rings | As required, based on inspection |
| **Remedial Work** | **Frequency** |
| Reconstruct trenches and/or replace or clean void fill if performance deterioration or failure occurs | As required |
| Replacement or clogged geotextiles | As required |

*Swales*

Swales are linear, flat bottomed grassed or vegetated channels that convey water from one place to another which can also store water and allow it to soak into the ground. Table 9 provides details of the maintenance requirements.

**Table 9 - Swales**

| General Requirements | Frequency |
|---|---|
| Mow amenity grass access paths and verges surrounding swales at 35-50mm minimum and 75mm maximum or as specified | Monthly or as required |
| Mow swales at 100mm with 150mm maximum to filter and control runoff in normal grass swales removing first and last cut in season if grass is longer than 150mm removing cuttings to wildlife piles on site | Monthly or as required |
| Where marsh or wetland develops in the swale due to wet conditions then cut annually, or as required, at 100mm removing cuttings to wildlife piles on site | Annually (or as required) |
| **Occasional Tasks** | **Frequency** |
| Where there is a build-up of silt on the swale or at inlets, i.e. 50mm or more above the design level, then remove and spread on site. Undertake when ground is damp in autumn or early spring and transplant turf and overseed to original design levels | As required |
| Spread excavated material on site above SuDS design profile, e.g. top of banks, in accordance with the Environment Agency's Waste Exemption Guidance | As required |
| Clear perforated pipework of blockages | As required |
| **Remedial Work** | **Frequency** |

| | |
|---|---|
| All damage to be made good to design profile unless there is a design flaw | As required |

*Below Ground Drainage Pipes*

Below ground drainage pipes convey water to the SuDS system. They should be free from obstruction at all times to allow free flow. Table 10 provides details of the maintenance requirements.

**Table 10 - Below Ground Drainage Pipes**

| General Requirements | Frequency |
|---|---|
| Inspect and identify any areas that are not operating correctly. If required, take remedial action | Monthly for the first 3 months then annually |
| Remove debris from the catchment surface (where it may cause risks to performance) | Monthly |
| Remove sediment from pre-treatment inlet structures and inspection chambers | Annually or as required |
| Maintain vegetation to designed limits within vicinity of below ground drainage pipes and tanks to avoid damage to system | Annually or as required |
| **Occasional Tasks** | **Frequency** |
| Inspect all inlets, outlets, and vents to ensure that they are in good condition and operating as designed | Annually |
| Survey inside of pipe runs for sediment build up and remove if necessary | Every 5 years or as required |
| **Remedial Work** | **Frequency** |
| Repair physical damage if necessary | As Required |

*Inlet Structures and Inspection Chambers*

Inlet structures such as rainwater downpipes, road gullies and channel drains. They should be free from obstruction at all times to allow free flow through the SuDS system. Inspection chambers and rodding eyes are used on bends or where pipes come together. They allow access and cleaning to the system if necessary. Table 11 provides details of the maintenance requirements.

**Table 11 - Inlet Structures and Inspection Chambers**

| General Requirements | Frequency |
|---|---|
| Inspect rainwater downpipes, channel drains and road gullies, removing obstructions and silt as necessary | Monthly |
| Check there is no physical damage | Monthly |
| Strim vegetation 1m minimum surrounding structures and keep area free from silt and debris | Monthly |
| Remove cover and inspect, ensuring that the water is flowing freely and that the exit route for water is unobstructed | Annually |
| Removed debris and silt | Annually |
| **Occasional Tasks** | **Frequency** |
| Check topsoil levels are 20mm above edges of chambers to avoid mower damage. | As Required |
| **Remedial Work** | **Frequency** |

| | |
|---|---|
| Repair physical damage if necessary | As Required |

## 4.11 Health and Safety

In order to comply with the Construction (Design and Management) Regulations (CDM) 2015, SuDS designers must assess all the foreseeable risks during the construction phase and during the ongoing maintenance of the schemes.

Contractors and those responsible for future maintenance will be made aware of the risks by the Site owner, keeping a record of the key health and safety factors that will need to be managed during future ongoing maintenance works. During construction, the residual risks should be identified, and an action plan developed to deal with them appropriately.

All those responsible for maintenance should also take the appropriate health and safety precautions for all maintenance activities, this should additionally include lone working when relevant, and risk assessments should be undertaken for all activities.

## 4.12 Spillage – Emergency Action

Most spillages on development are of compounds that do not pose a serious risk to the environment if they enter the drainage in a slow and controlled manner with time available for natural breakdown in a treatment system. Therefore, small spillages of oil, milk or other known organic substances should be removed where possible using soak mats as recommended by the Environment Agency, with residual spillage allowed to bioremediate in the drainage system.

In the event of a serious spillage, either by volume or of unknown or toxic compounds, then isolate the spillage with soil, turf or fabric and block outlet pipes from chamber(s) downstream of the spillage with a bung(s) (A bung for blocking pipes may be made by wrapping soil or turf in a plastic sheet or closely woven fabric).

## 4.13 Conclusion

There should be no perceivable changes to the upstream or downstream hydrology and to flood risk as a result of the proposals. In terms of surface water runoff, the proposals will not increase the impermeable area on the Site, as the size of the impermeable areas are considered to be negligible in the context of the site areas.

Research into the impact of solar farm panels on runoff rates and volumes indicates that solar panels do not have a significant impact on runoff volumes, peak rates or time to peak rates when the ground below the panels is vegetated. Therefore, with well-maintained grass underneath the panels, the solar panels themselves will not have a significant impact on the runoff volumes, peaks or time to peak.

# 5.0 RISK MANAGEMENT

## 5.1 Introduction

The flood risk at this location is considered suitable for the Proposed Development within the NPPF. In this flood zone, developers and local authorities should seek opportunities to reduce the overall level of flood risk in the area through the layout and form of the development and the use of flood mitigation measures.

The flooding sources will be mitigated on the Site by using a number of standard techniques, and mitigation strategies to manage and reduce the overall flood risk at the Site. This will ensure the development will be safe and there is:

- Minimal risk to life;
- Minimal disruption to people living and working in the area;
- Minimal potential damage to property;
- Minimal impact of the Proposed Development on flood risk generally; and;
- Minimal disruption to natural heritage.

## 5.2 Development Platform Level/Critical Equipment

The Site will be flood free during the 1 in 100 year (+50%) and 1 in 1000 year events. The BESS, solar arrays and vulnerable infrastructure will be located above the ground level. The modules are raised off the ground such that the leading edge of each panel will be approximately 0.80m off the ground and the top edge up to 2m maximum in height off the ground. Consequently, the panels will be unaffected by floodwater depths.

The frame supporting the solar panels should not impede overland flow or reduce flood storage capacity, as it would only be the legs and concrete sleepers which would be within the path of overland flow or floodwaters. The legs are of narrow dimension (60mm) and well-spaced (minimum of 3m apart).

The panels are designed so that they have minimal foundations this limits disturbance of soils/loss of resource and reduces the volume of concrete required. This would also therefore limit the potential for disruption of surface and groundwater flows.

The ancillary structures: substation, transformers etc are also small structures and therefore only require shallow foundations, limiting ground disturbance and disruption to overland flow routes. The proposals are based on maintaining the existing drainage, the structures associated with the solar farm will introduce only small areas of impermeable surfacing. It is not proposed to install new drainage infrastructure but maintain existing Greenfield runoff rates.

Where possible existing farm access tracks will be used, and the position of new access tracks will avoid the necessity for watercourse crossings to avoid changes to in-channel flow and disturbance of the riparian habitat.

## 5.3 Flood Resilience and Resistance

The design of the layout has factored in that the Site is potentially at risk from an extreme event and as such the implementation of flood resilience and resistance methods should be assessed.

In the event of a flood the plant will be shut down and isolated from the power grid. Water levels on Site will be monitored and data sent back to the control room enabling the early action required to shut down and isolate the Site. Severe local flooding of the Site would mean that the Site would not be required to be operational and would be closed down until the floodwaters have receded.

All external doors and windows will be constructed from hard wearing materials. All buildings / structures (are of hard wearing materials and will be sealed against water ingress. The floor of the buildings will be constructed from concrete hardstanding which will be resilient to floodwater.

## 5.4 Flood Plan

A Flood Plan outlining the precautions and actions you should take when a flood event is anticipated to help reduce the impact and damage flooding may cause will be developed. Sensible precautions would include raising electrical items and irreplaceable items off the ground or where possible moving them to higher ground and turning off utilities. In the event of a flood the plant will be shut down and isolated from the power grid.

The Flood Plan is a 'living' document and therefore should be periodically reviewed and updated to provide advice and guidance to occupants in the event of an extreme flood. The Flood Plan will therefore reduce the vulnerability of the Site to flooding and make visitors to the Site aware of the mechanisms of flooding at the Site.

## 5.5 Safe Access and Egress Route

The NPPF requires that, where required, safe access and escape is available to / from new developments in flood risk areas. Access routes should be such that occupants can safely access and exit Sites in design flood conditions. These routes must also provide the emergency services with access to the development during a flood event and enable flood defence authorities to carry out any necessary duties during the period of flood.

The Site will be flood free during the 1 in 100 year (+50%) and 1 in 1000 year events. It should be noted that the majority of the time, the Proposed Development will be unmanned, except for occasional routing maintenance visits. A safe access and egress route, including emergency access can be maintained for vehicles and / or by foot. The Site is at such a ground level that it would only flood in the most extreme flood event. Likewise, the access and egress route will remain dry in all but these most extreme scenarios. A safe access and egress route with minimum water depths would be possible for many hours if not days. This would provide more than an adequate amount of time for the Site to be evacuated, if required. Therefore, safe access and egress can be maintained in accordance with the NPPF and Environment Agency guidance.

## 5.6 Buffer Strip/Easement

No works will occur within 9m of drainage ditches, as per the Trent Vally IDB guidance. Consent for works to drainage ditches or within 9m will be required from Trent Vally IDB.

## 5.7 Flooding Consequences

The mitigation measures detailed above show that the flood risk can be effectively managed and therefore the consequences of flooding are acceptable. The Site is unlikely to flood except in extreme conditions.

# 6.0 SEQUENTIAL APPROACH

## 6.1 Sequential Test

The risk-based Sequential Test in accordance with the NPPF aims to steer new development to areas at the lowest probability of flooding (i.e. Flood Zone 1). The NPPF states that developments located within the floodplain should apply a risk based sequential test in order to steer the Proposed Development towards areas classed as having a lower probability of flooding. The NPPF does, however, acknowledge that under certain circumstances it may not be possible to locate the development on land identified as having a lower risk of flooding (Flood Zone 1) but the benefits of the development should be clearly stated.

The Environment Agency modelled data shows that the Site, including the access road, will not be inundated with floodwater for all events up to and including the 1 in 100 year (+50%) and 1 in 1000 year events. Between the Site and the River Trent, the ground levels along Main Road (A617) rise to above 12.50mAOD i.e. above the modelled water levels for the 1 in 100 year (+50%) and 1 in 1000 year events. The Site will be flood free during the 1 in 100 year (+50%) and 1 in 1000 year events. Therefore, the Site will also be flood free during the design event for the Site i.e. the 1 in 100 year (+39%) event. The Site, including the access road, should therefore, be designated as being located within Flood Zone 1 and not Flood Zones 2 or 3.

A criteria based approach to Site selection has been undertaken which is detailed within Section 5 the Planning Statement. Figure 11 shows the Constraints Map for the Proposed Development.

An important aspect of solar farm and BESS development is having access to the local distribution network, or 'grid'. To export electricity generated by a solar farm there must be sufficient capacity on the network to accommodate the additional power from the development. If there is insufficient capacity or the distribution network infrastructure is substandard the network will fail.

As part of the grid application process, the distribution network operator (DNO) provides a point of connection on the network or grid where the power from the solar farm and BESS must connect. It is important that these developments are close to the point of connection, due to:

- Excessive costs of the cable and the trenching works;
- Requirement for easements to enable the crossing of third-party land, and necessary works in the highway which may disrupt local communities; and
- Voltage drops and unwanted energy losses resulting from long cable runs which cause further difficulties for the distribution network operators.

The industry-standard approach is to secure sites within 3.50km of a grid connection. The cable run from the deployment area to the point of connection is less than 1.50km, or circa 1km 'as the crow flies.'

Consideration of land closer to the point of connection has been given but discounted as there are significant areas of higher flood risk, proximity to built-up areas and limited availability of landowners willing to lease their land.

A detailed soil survey has determined that the majority of the proposal Site is Best and Most Versatile (BMV) Agricultural Land having 92% as grade 2 and grade 3a. The remaining 8% of land is grade 3b and non-agricultural. In justifying the location of the proposal site consideration has been given to other locations with lower or equivalent BVM grades.

The Site proposals remain consistent with the relevant planning policies and are not at odds with the current use of the Site and can only enhance and preserve the employment/power generating base which currently exists. The wider area surrounding the Site is affected by a very similar, and in many cases, higher risk of flooding.

Similar developments on any Site outside a Flood Zone will not offer any advantage vis-a-vis flooding. Consequently, application of the Sequential Test demonstrates that there is no measurable advantage to constructing the Proposed Development elsewhere. The Site needs to be situated at this location to enable a connection to the electricity power network .

The Council's objectives are to sustain and enhance the vitality and viability of the region, and improving the overall quality of life. This is underpinned by the quality of the physical environment, social well-being and economic and environmental improvements. The Council seeks to grant permission for developments that add to the vitality and viability of the region. This Site will help to regenerate the region and will help to deliver these objectives. This Site will help encourage economic impetus.

The Proposed Development can only be delivered where Site conditions are favourable, and a series of criteria are satisfied. These can be summarised as follows:

- The Proposed Development must be located close to a point of connection that has capacity to both export and import the requisite amount of electrical energy. Pressure on the grid results in significant constraints on the availability of sites (UK wide) which can import and export energy from the grid and have sufficient grid connection capacity. In essence, whilst there are a reasonable number of connection points that can export power, the number that can import power is particularly limited.

- The Proposed Development must be located proximate to the point of connection (i.e. cable or existing substation) to minimise transmission losses. As BESSs both export and import energy from / to the grid, transmission losses occur during both the import and export phases, therefore doubling the impact of any losses that occur.

- Finally, the Proposed Development can only be delivered where there is land available for purchase / lease for the development, at reasonable and acceptable commercial terms.

With regard to the above, and other planning considerations, the nearby substation has capacity to accommodate the Proposed Development. Furthermore, the Proposed Development is located on land that is commercially available for development, should planning permission be granted.

Section 5 of The Planning Statement concludes *"It is clear from the constraint plan and above that there is no unconstrained within the search area that is of a lower BMV grade. As such is it considered that the proposal site is the most suitable site that can viably connect into the substation at Staythorpe."*

No 'reasonably available' alternative sites have been identified within the Site selection process. From the above it is shown that there are overriding sustainability reasons for the development to be granted planning permission. The development proposals should therefore be considered by the LPA to satisfy the Sequential Test as set out in the NPPF.

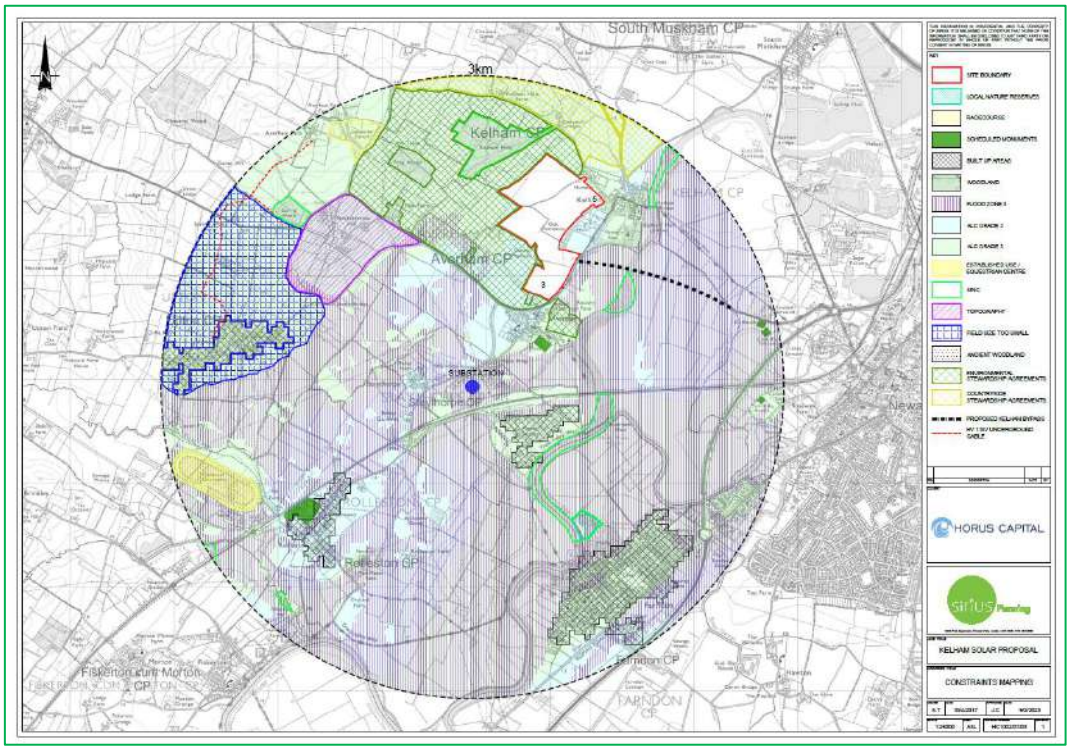



**Figure 11 - Constraints Map**

## 6.2 Exception Test

The proposed use is classified as 'essential infrastructure'. The proposed access road can be classified as 'less vulnerable'. It should be noted that only a small section of the access road will be located within Flood Zone 3, the built development (i.e. essential infrastructure) will not be located within Flood Zone 3.

The Environment Agency modelled data shows that the Site, including the access road, will not be inundated with floodwater for all events up to and including the 1 in 100 year (+50%) and 1 in 1000 year events. Between the Site and the River Trent, the ground levels along Main Road (A617) rise to above 12.50mAOD i.e. above the modelled water levels for the 1 in 100 year (+50%) and 1 in 1000 year events. The Site will be flood free during the 1 in 100 year (+50%) and 1 in 1000 year events. Therefore, the Site will also be flood free during the design event for the Site i.e. the 1 in 100 year (+39%) event. The Site, including the access road, should therefore, be designated as being located within Flood Zone 1 and not Flood Zones 2 or 3.

Applications for 'essential infrastructure' and 'less vulnerable' uses within Flood Zones 1, 2 and 3 are not subject to the Exception Test as confirmed within Table 2 of this report and Table 3 of the PPG.

## 6.3 Summary

The development proposals should therefore be considered by the LPA to satisfy the Sequential and Exception Tests as set out in the NPPF.

# 7.0 SUMMARY AND CONCLUSIONS

## 7.1 Introduction

This report presents a FRA in accordance with the NPPF for the Proposed Development of a Solar Farm and Battery Energy Storage System (BESS) on land to the west of Main Road, Kelham ("the Site").

This FRA identifies and assesses the risks of all forms of flooding to and from the development and demonstrates how these flood risks will be managed so that the development remains safe throughout the lifetime, taking climate change into account.

## 7.2 Flood Risk

The Site is unlikely to flood except in extreme conditions. The principal flood risk posed to the Site is from fluvial flooding from the River Trent. The majority of the Site is located within Flood Zone 1 and therefore have a 'low probability' of fluvial flooding. There are several small areas of the Site which are located within Flood Zone 2 and therefore have a 'medium probability' of fluvial flooding and only a small section of the access road to the south is located within Flood Zone 3 and therefore have a 'high probability' of fluvial flooding.

The proposed use is classified as 'essential infrastructure'. The proposed access can be classified as 'less vulnerable'. It should be noted that only a small section of the access road will be located within Flood Zone 3, the built development (i.e. essential infrastructure) will not be located within Flood Zone 3.

The Environment Agency modelled data shows that the Site, including the access road, will not be inundated with floodwater for all events up to and including the 1 in 100 year (+50%) and 1 in 1000 year events. Between the Site and the River Trent, the ground levels along Main Road (A617) rise to above 12.50mAOD i.e. above the modelled water levels for the 1 in 100 year (+50%) and 1 in 1000 year events. The Site will be flood free during the 1 in 100 year (+50%) and 1 in 1000 year events. Therefore, the Site will also be flood free during the design event for the Site i.e. the 1 in 100 year (+39%) event. The Site, including the access road, should therefore, be designated as being located within Flood Zone 1 and not Flood Zones 2 or 3.

Given the scale and nature of the fluvial flooding sources it has been concluded that the risk of fluvial flooding is considered to be of low significance. A secondary flooding source has been identified which may pose a low significant risk to the Site. This is:

- Surface Water Flooding

The flooding source will only inundate the Site to a relatively low water depth and water velocity, will only last a short period of time, in very extreme cases and will not have an impact on the whole of the Site. The risk of flooding from all sources will be further managed and mitigated by using a number of mitigation measures to manage and reduce the overall flood risk at the Site.

The Site will be flood free during the 1 in 100 year (+50%) and 1 in 1000 year events. The Site, including the access road, should therefore, be designated as being located within Flood Zone 1 and not Flood Zones 2 or 3. The Proposed Development will have no impact on flood risk and the overall direction of the movement of water will be maintained within the developed Site and surrounding area. There will no net loss in flood storage capacity. Any changes in topography will be minor and will not be located within the floodplain.

In conclusion, the flood risk to the Site can be considered to be limited, the Site is unlikely to flood except in very extreme conditions.

## 7.3 SuDS Strategy

The objective of this SuDS Strategy is to ensure that a sustainable drainage solution can be achieved which reduces the peak discharge rate to manage and reduce the flood risk posed by the surface water runoff from the Site. The SuDS Strategy takes into account the following principles:

- No increase in the volume or runoff rate of surface water runoff from the Site.
- No increase in flooding to people or property off-site as a result of the development.
- No surface water flooding of the Site.
- The proposals take into account a 40% increase in rainfall intensity due to climate change.
- Maintain / improve surface water quality.
- Provide amenity and biodiversity benefits.

In line with adopting a 'management train' it is recommended that water is managed as close to source as possible. For the purposes of this assessment, discharging surface water runoff to the ground via infiltration is the preferred option for the discharge of surface water runoff from the Site, with a secondary option of discharge to a drainage ditch, at Greenfield runoff rates. This will reduce the size and cost of infrastructure further downstream and also shares the maintenance burden more equitably. The Outline SuDS Strategy will take the form of:

- Permeable surfaces - crushed stone.
- Infiltration trenches.
- Swales.

One of the aims of the NPPF is to provide not only flood risk mitigation but also to maximise additional gains such as improvements in runoff quality and provision of amenity and biodiversity. Systems incorporating these features are often termed SuDS and it is the requirement of NPPF that these are considered as the primary means of collection, control and disposal for storm water as close to source as possible.

The principle applied in the design of storage is to limit the discharge rate of surface water runoff from the developed Site for events of similar frequency of occurrence to the same peak rate of runoff as that which takes place from a Greenfield site prior to development. It would not be practical to include a pond, or lagoon within the Site it would also not be sustainable to install a green roof on the buildings/structures.

The SuDS Strategy will reduce peak flows, the volume of runoff, and slow down flows and will provide a suitable SuDS solution for this Site. The adoption of a SuDS Strategy for the Site represents an enhancement from the current conditions as the current surface water runoff from the Site is uncontrolled, untreated, unmanaged and unmitigated. In adopting these principles, it has been demonstrated that a scheme can be developed that does not increase the risk of flooding to adjacent properties and development further downstream.

## 7.4 Risk Management

The flooding sources will be mitigated on the Site by using a number of standard techniques, and mitigation strategies to manage and reduce the overall flood risk at the Site. These are:

**Development Platform Level/Critical Equipment:** The Site will be flood free during the 1 in 100 year (+50%) and 1 in 1000 year events. The BESS, solar arrays and vulnerable infrastructure will be located above the ground level. The modules are raised off the ground such that the leading edge of each panel will be approximately 0.80m off the ground and the top edge up to 3m in height off the ground. Consequently, the panels will be unaffected by floodwater depths.

The frame supporting the solar panels should not impede overland flow or reduce flood storage capacity, as it would only be the legs which would be within the path of overland flow or floodwaters. The legs are of narrow dimension (60mm) and well-spaced (minimum of 3m apart).

The panels are designed so that they have minimal foundations this limits disturbance of soils/loss of resource and reduces the volume of concrete required. This would also therefore limit the potential for disruption of surface and groundwater flows.

The ancillary structures: substation, transformers etc are also small structures and therefore only require shallow foundations, limiting ground disturbance and disruption to overland flow routes. The proposals are based on maintaining the existing drainage, the structures associated with the solar farm will introduce only small areas of impermeable surfacing. It is not proposed to install new drainage infrastructure but maintain existing Greenfield runoff rates.

Where possible existing farm access tracks will be used, and the position of new access tracks will avoid the necessity for watercourse crossings to avoid changes to in-channel flow and disturbance of the riparian habitat.

**Flood Resilience and Resistance:** In the event of a flood the plant will be shut down and isolated from the power grid. Water levels on Site will be monitored and data sent back to the control room enabling the early action required to shut down and isolate the Site. Severe local flooding of the Site would mean that the Site would not be required to be operational and would be closed down until the floodwaters have receded.

All external doors and windows will be constructed from hard wearing materials. All buildings / structures (are of hard wearing materials and will be sealed against water ingress. The floor of the buildings will be constructed from concrete hardstanding which will be resilient to floodwater.

**Flood Plan:** A Flood Plan outlining the precautions and actions you should take when a flood event is anticipated to help reduce the impact and damage flooding may cause will be developed. Sensible precautions would include raising electrical items and irreplaceable items off the ground or where possible moving them to higher ground and turning off utilities. In the event of a flood the plant will be shut down and isolated from the power grid.

The Flood Plan is a 'living' document and therefore should be periodically reviewed and updated to provide advice and guidance to occupants in the event of an extreme flood. The Flood Plan will therefore reduce the vulnerability of the Site to flooding and make visitors to the Site aware of the mechanisms of flooding at the Site.

**Safe Access and Egress Route:** The Site will be flood free during the 1 in 100 year (+50%) and 1 in 1000 year events. It should be noted that the majority of the time, the Proposed Development will be unmanned, except for occasional routing maintenance visits. A safe access and egress route, including emergency access can be maintained for vehicles and / or

by foot. The Site is at such a ground level that it would only flood in the most extreme flood event. Likewise, the access and egress route will remain dry in all but these most extreme scenarios. A safe access and egress route with minimum water depths would be possible for many hours if not days. This would provide more than an adequate amount of time for the Site to be evacuated, if required. Therefore, safe access and egress can be maintained in accordance with the NPPF and Environment Agency guidance.

**Buffer Strip/Easement:** No works will occur within 9m of drainage ditches, as per the Trent Vally IDB guidance. Consent for works to drainage ditches or within 9m will be required from Trent Vally IDB.

## 7.5 Sequential Approach

No 'reasonably available' alternative sites have been identified within the Site selection process. From the above it is shown that there are overriding sustainability reasons for the development to be granted planning permission. The development proposals should therefore be considered by the LPA to satisfy the Sequential Test as set out in the NPPF.

Applications for 'essential infrastructure' and 'less vulnerable' uses within Flood Zones 1, 2 and 3 are not subject to the Exception Test as confirmed within Table 2 of this report and Table 3 of the PPG.

The development proposals should therefore be considered by the LPA to satisfy the Sequential and Exception Tests as set out in the NPPF.

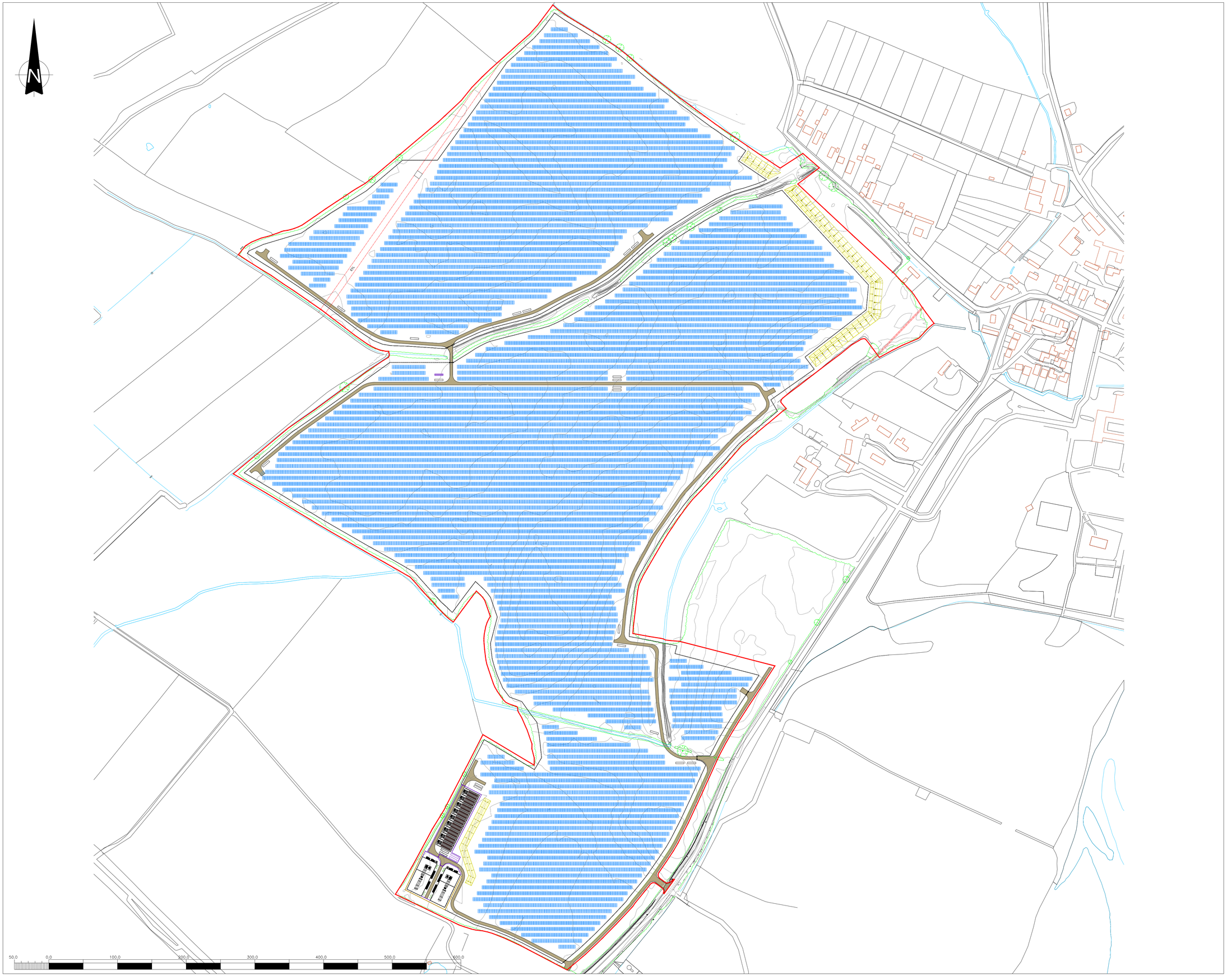
## 7.6 Conclusion

In conclusion, the Proposed Development, would be expected to remain dry in all but the most extreme conditions. Providing the recommendations made in this FRA are instigated, flood risk from all sources would be minimised, the consequences of flooding are acceptable and the development would be in accordance with the requirements of the NPPF.

This FRA demonstrates that the proposed development would be operated with minimal risk from flooding, would not increase flood risk elsewhere and is compliant with the requirements of the NPPF. The development should not therefore be precluded on the grounds of flood risk.

# APPENDICES

# APPENDIX 1 – Proposed Site Layout






**KEY**

- SITE BOUNDARY
- GROUND CONTOURS WITH EXISTING BUND REMOVED
- EXISTING OVERHEAD CABLES
- EXISTING HEDGES
- EXISTING TREES
- PROPOSED PV PANELS
- PROPOSED 2.4m HIGH PALADIN FENCE
- PROPOSED 2.4m HIGH PALISADE FENCE
- PROPOSED 2.0m HIGH DEER FENCE
- PROPOSED 4m HIGH ACOUSTIC FENCE
- PROPOSED 2m HIGH CLOSE BOARDED TIMBER FENCE
- PROPOSED ACCESS TRACKS
- PROPOSED SCREENING BUND
- PROPOSED TRANSFORMER
- PROPOSED SWITCHROOM
- PROPOSED SPARES CABIN
- PROPOSED BATTERY, TRANSFORMER AND INVERTER
- PROPOSED DNO CABIN
- PROPOSED DNO SWITCHROOM
- PROPOSED DNO MAST
- PROPOSED 132kV SUBSTATION

| REV | DESCRIPTION | DATE | BY |
|---|---|---|---|
| | | | |

**CLIENT**

**ASSURED ASSET 2 LIMITED**

siriUS Planning
4245 Park Approach, Thorpe Park, Leeds. LS15 8GB. 0113 264 9960

**JOB TITLE**

KELHAM SOLAR FARM AND BESS

**DRAWING TITLE**

SITE LAYOUT

| DRAWN | DATE | APPROVED | DATE |
|---|---|---|---|
| S.T | 19/9/2023 | J.C | 19/9/2023 |

| SCALE | SHEET | DRAWING NUMBER | REVISION |
|---|---|---|---|
| 1:2500 | A1L | HC1002/05/03 | 0 |